SCIENTIFIC AMERICAN SUPPLEMENT. No 1207

Scientific American, established 1845.
Scientific American Supplement. Vol. XLVII. No. 1207.

NEW YORK, FEBRUARY 18, 1899.

Scientific American Supplement. $5 a year.
Scientific American and Supplement. $7 a year.

TWIN SCREW STEAM YACHT "ATMAH."

THE LARGEST AND MOST NOTABLE YACHT BUILT IN GREAT BRITAIN LAST YEAR (1898).

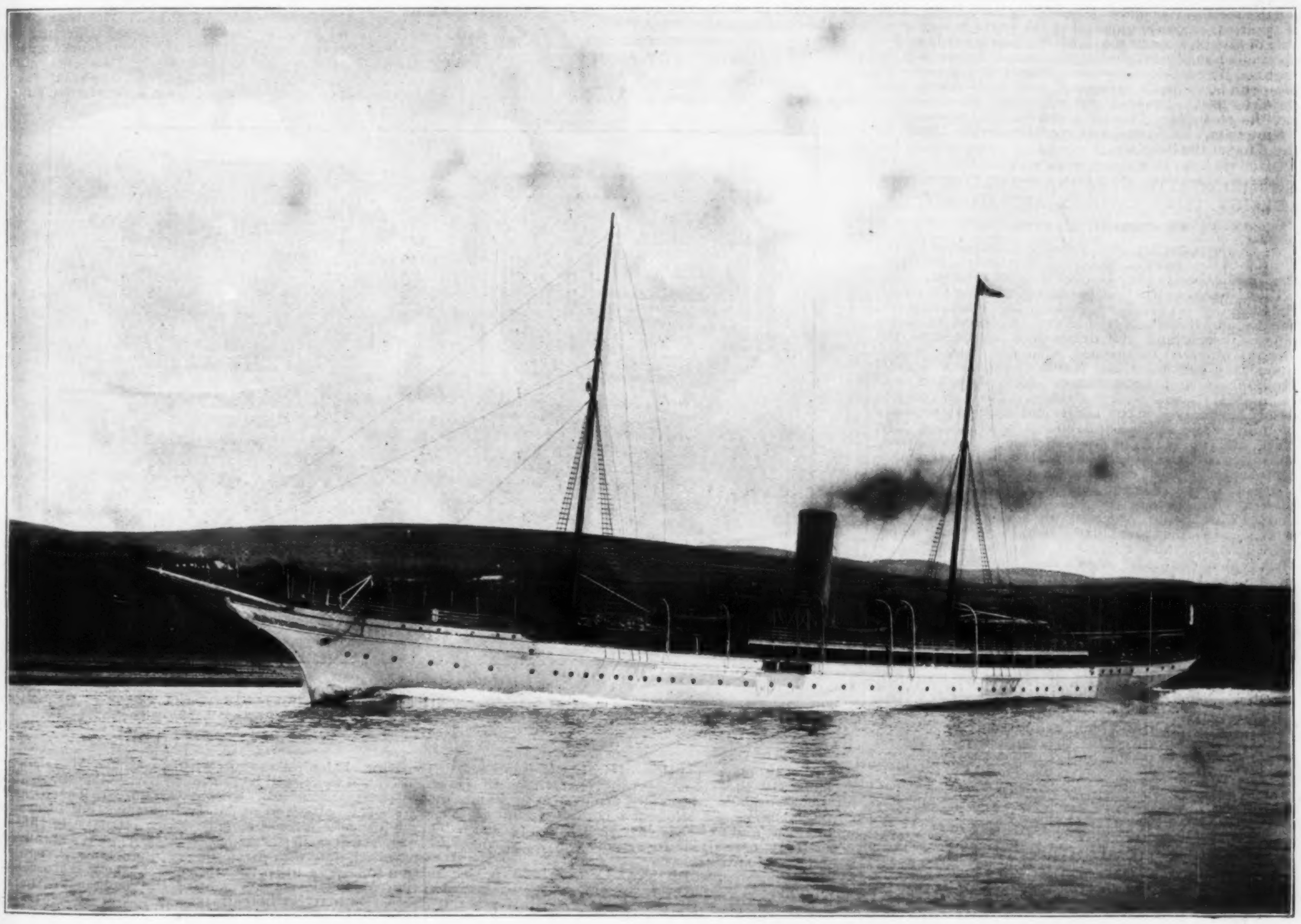
THE magnificent twin screw steam yacht "Atmah" was the largest and most notable steam yacht built last year (1898) in Great Britain or Ireland. She was constructed to the designs of Mr. George L. Watson (Glasgow) by the Fairfield Shipbuilding and Engineering Company (Limited), Govan, Scotland, to the order of Baron Edmond de Rothschild, 41 Faubourg St. Honore, Paris, France. The Rothschild family are great yachting people, and with the "Atmah" included they own among themselves no less than 4,645 tons of yachting. Baron Arthur de Rothschild, of Paris, is the owner of the steam yacht "Eros," 737 tons; Baron Edouard de Rothschild (Paris) is the owner of the sailing yachts "Bettina," 31 tons, "La Fleche," 114 tons, and "Pompaneau," 3 tons; Baroness Adolphe de Rothschild (Paris) owns the 71-ton steam yacht "Gitana;" Baron Nathaniel de Rothschild, of Vienna, Austria, owns the steam yacht "Veglia," 1,111 tons; while the steam yacht "Rona," 1,023 tons, flies the flag of Baron Ferdinand de Rothschild, of Waddeston, Aylesbury, England. The above statement, therefore, goes to show that five yachts sail under the French flag, one under the Austrian, and one under the British colors.

The "Atmah," is the twelfth largest yacht in the world and is of 1,555 tons (Thames yacht measurement). To compare her with American-owned yachts, she is 9 tons smaller than Eugene Higgins' "Varuna," or 54 tons less than Howard Gould's new "Niagara." The dimensions of the "Atmah" are: Length on load water line, 270 feet; between perpendiculars, 283·4 feet; breadth (moulded), 34·25 feet; depth (moulded), 19·25 feet. Net tonnage, 612·43, while her gross tonnage is 1,333·90 tons. She was built under special survey and classed 100 A 1 at Lloyds and 1 3-311 Bureau Veritas in the yacht register of both societies. The hull is of steel, with side bar keel and bilge keels, clipper stem, and elliptic stern, topgallant forecastle, and raised quarter deck. The bottom of the vessel is of the semi-longitudinal character of construction, with an inner bottom fitted under the main coal bunkers, forming water ballast tanks for a length of about 50 feet. There are seven watertight bulkheads throughout the ship. On the shade deck provision is made for carrying several quick-firing guns. There is a commodious smoking room in the deck house aft, and the wheel house and chart room are forward of the funnel, with a flying bridge above. The main entrance to the saloon is situated at the forward end of the deck house on the main deck, and abaft of this there is a large state room with dressing room adjoining and the captain's cabin. The after deck house incloses a large state room and entrance to the dining room, as well as a stair leading to the smoking room on the shade deck.

The galleys are fitted up in the after part of the house. The owner's and guests' accommodation, which includes owner's state room, five guests' cabins, drawing room, bath rooms and lavatories, are situated on the cabin deck, forward of the boiler space. The dining room, with pantry adjoining, is abaft the engine space, with a passage leading alongside the casings to the owner's accommodation. Forward of the owner's and guests' apartments, on the same deck, accommodation and mess rooms are provided for the servants. The officers' quarters are arranged aft on the main deck. The crew's quarters are under and entered from the quarter-deck. The petty officers' quarters, with the usual conveniences, are situated under the forecastle. The carpenter's shop, steward's store room, ammunition room, sail lockers, stabling for bicycles, etc., are arranged in the forward end of the store room deck, at the after end of which there is a refrigerating chamber for fresh provisions. She carries a full complement of boats and life saving appliances. The steam and hand steering gear is placed under the quarter-deck and controlled from the flying bridge and quarter-deck. The steam windlass is on the main deck forward, with a vertical warping capstan above. A powerful steam warping capstan is situated aft on the quarter-deck. A system of hot water heating is carried throughout the ship, and a hot water supply is provided to all owner's and guests' rooms and lavatories, etc. A complete installation of electric light, including a powerful search light, is also provided. Accumulators are arranged in conjunction with the electric light.

Her machinery, which was supplied by the builders, consists of two sets of triple expansion engines, each set having four cranks and four cylinders, there being one high pressure, one medium pressure, and two low pressure cylinders. Their diameters are (2) 20½ inches, (2) 34 inches, and (4) 37 inches, with a piston stroke of 27 inches. The four cylinders are fitted with two slide valves, that for the high pressure and medium pressure being of the piston type and that for the two low pressures of the flat type. These valves work with two sets of ordinary link-motion valve gear. The reversing engines are of Brown's steam and hydraulic direct-acting type. The cooling water is supplied by two circulating pumps of the centrifugal type driven by two independent engines. The engine room is fitted with all the most modern appliances, including an evaporator for making fresh water for the boilers, an auxiliary condenser, a feed filter or grease extractor, and all the necessary fittings and connections to insure economy for working. All the shafting is of forged steel and hollow throughout. The propeller bosses and blades are of bronze, each blade being separate and adjustable. Steam is supplied by two single-ended boilers, each having four corrugated furnaces. The working pressure is 160 pounds, and each boiler is fitted with Quiggins internal feed heater. Fans and engines are fitted in the engine room, the air supply being led by suitable trunks to the ashpits of each furnace, and so arranged to work with forced or natural draught.

The "Atmah" was launched on the 4th of May, and it



TWIN SCREW STEAM YACHT "ATMAH," BUILT FOR BARON EDMOND DE ROTHSCHILD, PARIS.

was not until the middle of July that she ran her official speed trials on the Clyde. The photograph which we reproduce of the "Atmah" shows her running the measured mile off Skelmorlie on her official trial day. It was taken by Messrs. Maclure and Macdonald (Glasgow) and was the only picture secured of her while steaming at full speed. Her trials were most satisfactory in every manner, a mean speed of 16 knots being attained with her engines indicating 2,500 horse power. She had a continuous steaming trial for eight hours and the consumption of coal then was 1·82 pounds per I. H. P. per hour. The nominal power of her engines is 378 horse power. The grate surface is 1,878 and the heating surface is 5,645.

During her construction the "Atmah" was superintended on behalf of the owner by Henry Z. de Cordemoy, M.I.N.A., of Paris. Her trials having been completed, the "Atmah" left the Clyde for Southampton, where she remained for a few months having her interior fitted up in a most elaborate manner by London and Continental furnishers. She is now at Havre, her port of registry, and is at the present time one of the best appointed floating palaces afloat.

She is schooner rigged, and will when the wind is favorable set a square sail on the foremast. Her graceful and symmetrical lines are certain to come in for a good deal of admiration when she will be seen in the south of France early next year among the usual concourse of British and American yachts.

On Monday, November 21, 1898, Mr. Anthony J. Drexel, of Philadelphia, U. S. A., placed an order with Messrs. Scott & Company, shipbuilders and engineers, Greenock, Scotland, to build for him a magnificent twin screw steam yacht of 1,810 tons, Thames measurement. She is to be built to the designs of Mr. G. L. Watson, and will be of the following dimensions, viz.: Length on load waterline, 268 feet; breadth moulded, 36 feet, and depth moulded (least to main deck), 20 feet. She will be a spar deck vessel with clipper stem and square stern. Her machinery will consist of two sets of triple expansion engines of 4,750 horse power, capable of giving a mean speed of 16¾ knots per hour for about six hours' continuous steaming. Steam will be supplied by two double-ended boilers at a pressure of 200 pounds. She is to be delivered in Gourock Bay early in 1900. So that she will take over thirteen months to build. This new vessel will replace the "Margarita," 1,322 tons, sold recently by Mr. Drexel to the King of the Belgians.

UNITED STATES STEAMER "FULTON"—HER DESIGN, CONSTRUCTION AND CAPACITY.*

By CHARLES H. HASWELL, C.E.

As this was the first sea steamer constructed by the United States navy, a record of her design, construction, and capacity may be held to be of interest.

Upon her construction being ordered by Congress, the Secretary of the Navy, Mahlon Dickerson, directed the Commissioners of the Navy (a board of three officers discharging the duties now confided to the various bureaus) to proceed with the work; whereupon they detailed Chief Naval Constructor Samuel Humphreys and Constructors John Lenthall and Samual Hartt to design the vessel. They, in order to assure themselves of the additional required capacity of hull for the engines and boilers, assembled at New York, and, in default of the assistance of an engineer, consulted with James P. Allaire, the principal manufacturer of steam engines, who recommended two vertical overhead beam engines. Upon the exposure of such vital parts of the engines as the beams and connections being objected to, he replied that the chances of such exposed parts being injured by a shot were inconsiderable compared with the advantage of that type of engine for such a design and construction of hull as that proposed. They then advised with William Kemble, of the West Point Foundry Association, who gave them more of a dissertation on steam and engines than the recommendation of any one.

They then consulted with a manufacturer of steam engines whose plant was restricted to the construction of shop engines and light machines. He, in compliance with a very general and recognized law of individuals—that of holding his interest superior to that of others—recommended four non-condensing engines, set under the deck, and plain cylindrical boilers, which design being approved by the constructors, the additional capacity of the hull required was determined by the requirements of such a plant, and the following dimensions were decided upon, viz.: Length, 150 feet; beam, 34 feet 5 inches; hold, 12 feet 2 inches; and load line, 5 feet 3 inches.

When the hull was in frame, beamed, decked, and planked, an engineer was appointed temporarily to submit a design of engines and boilers, whereupon he designed two condensing engines, but from the insufficient depth of the hold for such an immersed midship section, the cylinders were necessarily set on the spar deck beams at a slight inclination thereto. Upon his design being approved he was, on July 12, 1836, appointed engineer in the service, and the superintendence of the construction of the engines and boilers of the vessel was confided to him.†

Upon consideration of the insufficiency of the capacity of the hull for engines and boilers of suitable capacity, and of the very insufficient capacity of coal hold, he addressed the Commissioners of the Navy, recommending that the hull be lengthened 20 feet (he preferred 30 feet, but was afraid to go to such an extent). Unfortunately and regretfully, his recommendation was not approved by the Chief Naval Constructor, to whom it was referred, added to which the engineer nearly lost his further employment for his temerity and such an alleged evidence of his incapacity.

Soon after, a contract was made with the West Point Foundry Association for two inclined condensing engines and the construction of four boilers, formed of the copper plates which were in a storehouse in the navy yard, and which had been procured in 1816 for the construction of a second "Flogobombus."

To accommodate the engines, two deck beams were cut out between the engine frame and one other scored. The water wheel shafts were about 3 feet above deck; the boilers, condensers, air pumps, etc., below. The volume of all of these reduced the capacity of the hold to such an extent that the fuel capacity was restricted to one day's steaming, added to which the weight of the engines and boilers was so much over that for which the hull was designed that the load draught was increased from 5·25 to 10·25 feet.

In April, 1838, the vessel, under the command of Capt. M. C. Perry, left New York for Washington. At Cape May her coal hold was filled with pine wood, at Norfolk a second supply of wood was obtained, and a third on the Potomac River.

Upon her arrival at Washington it was decided, in order to increase the quarters of her officers, to remove the cabin to the upper deck, and also that a hurricane deck should be added amidships, the weight of both of which additions increased her draught to 10·5 feet.

In September, under the command of Capt. Charles W. Skinner, she left Washington and reached Norfolk. While there the Department learned of its having been stated at a dinner table in New York that the British steamer "Great Western," then plying between that city and Liverpool, could beat her in speed. My deliberate opinion was called for, and, upon my comparison of the relative powers and immersed sections and lines of the two vessels, the result of my reply was such that the "Fulton" immediately left for New York. A few days after her arrival, due notice of the intention to test the speed of the two vessels having been given, the "Fulton," with several prominent merchants of the city on board, proceeded to the upper bay and awaited the "Great Western," as she left the city on her outward voyage. After allowing her to pass and have a full lead, the "Fulton" "opened" and passed her competitor so fast that to the observers on the "Fulton" she never closed the land abeam and ahead of her.

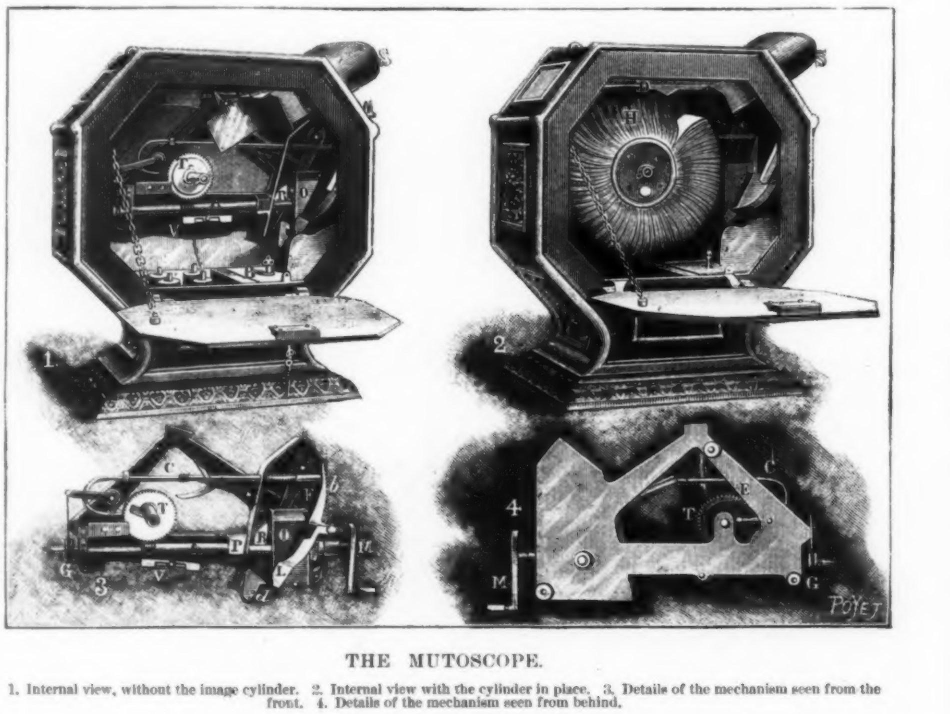
Soon after the engineer was detached from her for other service, and two years after, in order to reduce her draught of water, two of her boilers were removed and the remaining ones lengthened.

* Paper read before the American Society of Naval Engineers.

† This engineer was Mr. Haswell himself, who was thus the first engineer of the United States navy.—ED.

THE MUTOSCOPE.

IT is scarcely four years ago that the Edison kinetoscope made its appearance at Paris, and now there is hardly any more mention of it, for it has been dethroned by the cinematograph. In these times of automatic apparatus, the idea of a system set in motion through the introduction of a coin could not long be abandoned, and so it has just been taken up again by a company organized to exploit the mutoscope, an American apparatus.



THE MUTOSCOPE.

1. Internal view, without the image cylinder. 2. Internal view with the cylinder in place. 3. Details of the mechanism seen from the front. 4. Details of the mechanism seen from behind.

This apparatus, which may be left entirely to itself in any public place whatever, presents to the passer-by a slot into which is dropped a ten centime piece, by means of which, upon turning a crank, one may contemplate a scene full of life and animation. The result is not obtained by means of a strip of film, for the images are printed upon paper. The principle of the system is the same as that of the small pocket cinematograph sold by street venders, and consisting of a small book of which the leaves are made to pass rapidly before the eyes. Here, instead of a book, which would have had to be too large (for there are a thousand images), we have a sort of wheel, *H* (Fig. 2). All the sheets are united at the base upon an axis, and a sheet of Bristol board is interposed between each of them. The axis is mounted in a metallic box that may be revolved from the exterior by means of a winch. A finger, *D*, arranged at the top, catches and holds for an instant each image as it presents itself; and the ocular, *S*, is so arranged that the eyes see such image at the moment of its arrest. The substitution of one image for another is rapid enough to allow the successive impressions to persist upon the retina and give the illusion of motion. Were it a question of a parlor apparatus in which a family might contemplate at ease the living portrait of one of its members, the mechanism would include nothing else; but the question is slightly complicated as the case stands at present, in consequence of the necessity of collecting a fee.

As long as no money has been introduced, the winch, *M*, turns idly. The shaft, *A* (Figs. 1 and 3), that it actuates, through the pinion, *R*, is jointed at *P*, and ordinarily the endless screw, *V*, that it carries is disconnected from the toothed wheel, *T*, fixed to the axis of the cylinder upon which the images are mounted. But, as soon as a coin is dropped in, it is arrested at *L*, and a finger, *d*, to which the cam, *F*, gives a to and fro motion, passes over it, disengages it, and causes it to fall into the box, *B*. The resistance that the finger meets with in freeing the coin causes the rocking of a lever, *b*, which presses against a rod, *c*, of which the extremity enters a notch behind the wheel, *T*. This rod in its motion actuates a lever, *G*, which raises the shaft, *A*, and causes the screw, *V*, to engage with the teeth of the wheel, *T*. At this moment the images are carried along and pass before the eyes of the spectator. But after the rod has disengaged itself from the notch, it ascends an inclined plane behind the wheel, *T*, and follows it for an entire revolution and then falls back into the notch again. This motion causes the lever, *G*, to move in the opposite direction and disengages the screw, *V*, from the wheel. After this, it will be necessary to insert another coin in the slot in order to cause the cylinder to revolve again.

The light is furnished by an incandescent lamp supplied by batteries placed in the apparatus, and ignited by a contact only at the moment at which the revolution of the cylinder begins.

The spectator is absolute master of the rapidity of the revolution, and if a detail interests him particularly, he can arrest it and examine the latter at leisure. In a subject that represents a fencing bout, for example, he can, at a given moment, very slowly, analyze the thrust if he is desirous of seeing how it was executed. This feature possesses some interest, and makes the mutoscope not only an apparatus for amusement, but also a valuable instrument for the study of motion.

For the engravings and the above particulars we are indebted to La Nature.

General Superintendent A. W. Sullivan, of the Illinois Central, has notified employés that the regulation of their watches by other than the regular inspectors is likely to defeat the purpose of the inspection provided for by the company by interfering with the work and the records of the inspectors. The circular says: "As any standard watch purchased from an authorized inspector, which fails to run within a variation of thirty seconds a week, will be redeemed by the inspector, also by the manufacturer, without expense to the owner, there is no object to be gained in attempting to evade the inspection requirements. Any employé having a watch whose performance is inferior to the standard required, and who attempts by unauthorized regulation to impose upon the inspectors, practices a deception upon the management of the road. It is, therefore, required that hereafter conductors and other trainmen, engineers and firemen, shall not attempt to regulate their watches themselves, nor permit them to be regulated by any other person than the authorized inspectors. Failure to comply with these requirements will be considered sufficient cause for dismissal from the service."

The unit measurement of mechanical power was introduced by James Watt and called a "horse power." How this name originated is well told in the Magdeburger Zeitung. One of the first steam engines built by Watt was to furnish the power for the pumps in the brewery at Whitbread, England, which up to that time was supplied by horses. The contract called for as much power as furnished by a strong horse, and in order to get as powerful an engine as possible the brewer ascertained the amount of labor performed by a horse by working an exceptionally strong horse for full eight hours without a stop, urging the animal with a whip until it was exhausted, and thereby succeeded in raising 2,000,000 gallons of water. Considering the height of the reservoir, this labor represents the present unit of a "horse power," that is, the lifting of 168¾ pounds to a height of about 3 feet per second. This result, however, was obtained by exceptional methods and should not be considered the basis of measurement of mechanical power. Actually, the power of the average horse is barely sufficient to lift 65 to 70 pounds 3 feet high per second.

THE BELL-ELLIOTT TANGENT READING TACHEOMETER.

WE illustrate herewith a tacheometer theodolite, patented by Mr. G. J. Bell, of Carlisle, England. In order to measure distances with this instrument a level staff is erected at the distant point, and the instrument having been carefully leveled, two readings are taken on points of the staff, say 10 feet apart. Then, if θ be the inclination of the line of sight to the horizontal in making the upper reading, and φ the inclination in making the lower reading, we have obviously the horizontal distance of the staff:

$$H = \frac{10}{\tan\theta - \tan\varphi}$$

In Mr. Bell's instrument a ready means is provided for reading off these tangents direct from the instrument, without referring to tables. Subtracting the two readings from each other, and multiplying the reciprocal of the result by 10, gives at once the horizontal distance. The instrument is essentially an ordinary theodolite fitted with a trough compass, which can be used in the ordinary way. The two attachments which fit it specially for tacheometry consist of, in the first place, a very accurately divided scale rigidly secured to the upper parallel plate, and fitted with a micrometer adjustment, by which it can be shifted with certainty through a distance of $\frac{1}{15000}$ inch up to $\frac{1}{8}$ inch in the direction of its length. This scale can be read through a microscope fixed at right angles to the telescope as shown, and moving with the same, so that its axis makes the same angle with the prime vertical as the latter does with the horizontal plane of the instrument. A total reflection prism is used to deflect the line of vision through the microscope through 90 degrees, so as to bring the eyepiece into a convenient position for use. In making an observation the telescope is first aligned on the upper of the fixed marks on the level staff. The micrometer is then set to zero, and the division of the scale which is nearest to the cross wire of the microscope is read off through the latter. Say this was 19, then the natural tangent of the angle the line sight makes with the horizontal is 0·19 ±, a correction to be obtained from the micrometer head, which is by means of a vernier divided into 500 parts. This head is now rotated till the cross hair of the eyepiece exactly cuts the scale mark, and the reading of the head is then noted. Assume this to be 125. Then the natural tangent of the angle in question is 0·19125. On making similar readings for the lower mark on the staff the numbers might be say 17 and 823, then we should have

$$\tan\theta - \tan\varphi = 0{\cdot}01302.$$

The reciprocal of this is 0·76805, and the corresponding distance between staff and instrument would be 768·05 feet. This, perhaps, would be rather a long sight, and the accuracy of the instrument is, of course, the greater, the nearer the staff. We are indebted to London Engineering for the engraving and description.

THE BELL-ELLIOTT TANGENT READING TACHEOMETER.

THE USE OF GAS ENGINES FOR DYNAMO DRIVING.

By JOHN C. KELLEY.

I HAVE often been asked why it is that gas, gasoline, and oil engines are more largely used in England than in this country. For this condition of affairs various reasons may be given, the most obvious, perhaps, being that illuminating gas of, say, 700 heat units value costs about twice as much here as in England. For example, in Manchester, England, such gas costs about 60 cents per 1,000 cubic feet, while in New York city the present rate is $1.15 per 1,000 cubic feet. The result is that when any comparison of cost per horse power per hour is made with an economical type of steam engine the figure, 2 cents per horse power hour, obtained with a gas engine of good design, is much less favorable to the gas engine than its thermic efficiency entitles it to be for engines larger than say 40 or 50 horse power.

If, however, the rates for gas were to be reduced 50 per cent., as I believe might be done when used in large quantities, for fuel purposes, the gas engine even in small sizes would give power at a cost of 1 cent per horse power hour, and thus compare very favorably with the steam engine and give a wonderful impetus to the gas engine business.

In this connection I might say that in Boston it has recently (October 29, 1898) been arranged by the Brookline Gas Light Company with the city of Boston to reduce the price of gas for fuel purposes to 75 cents per 1,000 cubic feet, and to make graded prices for gas used for power purposes in gas engines, so that they will be for engines up to 100 horse power 1 1-5 cents per horse power hour; in gas engines from 100 to 200 horse power, 1 1-10 cents per horse power hour; and in engines of 200 horse power and upward, 1 cent per horse power hour. These prices, which are understood to take effect early in the spring, when the Massachusetts Pipe Line Gas Company will have completed their immense plant at Everett and will supply by contract coal gas of 18-candle power to the Brookline Company, will at once place gas engines, according to size, on an equality with steam engines using 5 to 6 pounds of coal per horse power hour, which fairly represents the coal consumption usually met with in steam engines of moderate size working under variable load.

In England not only is illuminating gas lower in price, but there is a much more general use made of producer gas to operate gas engines, even for powers as small as 20 horse power for factory and other service. Nothing corresponding to this is done here, except that for large powers, say 100 horse power and upward, a few gas producers are being installed for power stations and like service. Such engines compete in economy with our highest grades of steam engines.

But though progress is still slow, such plants will be widely used when once the fact is generally appreciated in this country as it is in England that a pound of coal gives far more power when made into gas and run through a gas engine than if burned under a boiler to generate steam for a steam engine. That the cost of fuel is almost a controlling factor in the question of installing gas engines is shown by the fact that the demand for large engines suited to our natural gas regions is steadily increasing.

As regards gasoline engines, improvements in the details, and particularly in the electric igniter, have placed this motor in position to compete with high grade steam engines, yielding as it does power at a cost of ¾ to 1 cent per horse power hour. The underwriters' requirements, however, restrict the gasoline engine to localities where there is sufficient space available to place the gasoline storage tank 30 feet away from any building. But for country houses and hotels, village water works, factories, or lighting stations the gasoline station seems just what the conditions demand, and there are a number of engines in use for such service, besides others to operate dynamos to charge storage batteries. The demand for gasoline engines is growing for out of town power plants, especially in the larger sizes for electric lighting and factory service.

The lessened sales over former years of the small sizes of gas engines, say 5 horse power and under, are, perhaps, due also in great measure to the competition of the electric motor. A small gas engine cannot be sold for the same price as a small motor, because it is a much more difficult and expensive machine to build. But it is found, as a rule, that those who install such machinery consider only the first cost and do not consider at all the cost of operating, which is a matter of vital importance. For example, a 3 horse power electric motor may be bought for, approximately, one-half what a first-class 3 horse power gas engine will cost. (The motor, it may be remarked, will weigh about 450 pounds, while the gas engine weighs about 1,500 pounds.) The difference in price may be, say, $150, while the difference in cost of operating may be, as shown by actual examples, as much as $200 to $240 per year, or nearly enough to pay for a gas engine the first year. In fact, careful comparison of costs of operating gas engines and motors doing the same or equivalent work has shown the motor to cost from two to three times as much to operate as a gas engine.

Were this item of cost based on actual charges for street current more generally known, instead of their being in New York city about ten times as many small motors as gas engines in service, the proportion might be reversed. Abroad the cost of operating is considered very carefully, and first cost in its due proportion, which may account, in part, for gas engines being used so much more largely than here.

As regards the application of gas engines to isolated electric lighting, a few instances may be cited. The direct connected plant of 500 lights capacity installed at the house of the American Society of Civil Engineers, 220 West Fifty-seventh Street, has been in service nearly a year and has proved satisfactory, the cost for fuel and attendance being about one-half that of street current, and the quality of light and regulation being excellent.

The two cylinder Nash engine gives two impulses on the crank shaft every two revolutions, instead of only one as in the single cylinder engine, and the governor is so sensitive that it automatically regulates the speed to within 2 per cent. from full load to no load. Besides this, a special coupling, which connects the engine and dynamo, is so adjusted that it is impossible for the speed of dynamo to vary but very slightly either way from normal speed before it is corrected by the coupling and the governor acting jointly. Regulation, in fact, is so close that the voltmeter shows less than one volt variation under changing loads.

At the civil engineer's house they installed a low pressure steam heating apparatus for warming the building, while gas engines are used only for the electric lighting. Some of our steam heating engineers were disposed to question the wisdom of this arrangement as compared with a steam lighting plant and steam for heating, but the result, in this case, has justified the choice and shown the economy of departing from standard practice, which has compelled the use of a steam plant, oftentimes, solely because it provided exhaust steam for heating, and because it was thought, no matter how wasteful the steam engine might be, it cost nothing for the steam heating.

The gasoline engine, particularly, which places country houses in an even more favorable position than those in the city with respect to electric lighting at a very moderate figure, I regard as especially promising. What we need just now is more intelligent appreciation, on the part of architects and owners, of what constitutes first class gas engine machinery and willingness to pay a fair price for it. The market is flooded with cheap gas engines, as it is with cheap steam engines; but while it is recognized that the severe requirements of electric lighting have wonderfully developed the steam engine and that nothing but the very best engines will serve, it does not seem yet generally appreciated that in like manner only a high grade gas engine will answer for electric lighting.—Elec. World.

In the recent conventions held by German ironmanufacturers, it was strenuously insisted upon that if Germany wished to compete with other countries in the markets of the world, a reduction of the present railway freight-charges would be absolutely necessary. More than one manufacturer, according to the Centralblatt der Walzwerke, compared the conditions in America with those in Germany. In the United States, it was remarked, the conditions were ideal; but it was also admitted that Americans are more energetic and bolder in their undertakings than Germans. It was further pointed out that the manufacturing industries of Germany would soon have to support the agricultural classes, which at present depend for their existence upon land gradually becoming impoverished. It was therefore asserted that, if the industrial conditions were not improved, these classes would emigrate and actually assist American manufacturers in driving out German ironmongers from the markets of the world. German manufacturers, it was stated, could not compete for any length of time with those of other countries, particularly of England, if the government did not reduce its present exorbitant railway freight-charges.

THE BRIDGES OVER THE TIBER IN ANCIENT ROME.

M. RONNA has recently published in the Bulletin de la Société d'Encouragement pour l'Industrie Nationale a most interesting paper upon the nature of the Tiber, in which he studies the work done in antiquity for the purpose of counteracting the effect of the periodical floods that occurred in this watercourse and its affluents, such as the Anio, and, at the same time, describes the various bridges constructed by the Romans to permit of crossing the river in the capital city. These ancient bridges, which were semicircular arched, very narrow, constructed of coarse materials and supported by piers of inordinate thickness, presented much of the character proper to those old structures in which resistance and solidity, rather than elegance, were sought before all else. Yet it cannot be denied that they might, in many respects, have served advantageously as models for all the stone bridges constructed in the ancient world. If, however, we consider that, through their heavy and massive installation, and, at the same time, that, through their badly chosen direction, contrary to that of the current, they frequently constituted a serious obstacle to the flow of the stream and caused eddies and a swelling of the water, we shall recognize the fact that they thus aggravated, in a large measure, inundations that were already terrible of themselves; whence it must be concluded that the art of bridge construction had not made the same progress as the other divisions of the building art. However this may be, these structures call forth our admiration none the less by the beautiful arrangement of the materials and by a solidity that, according to the expression of M. Tournon (recalled by M. Ronna), is attested by twenty centuries of resistance to the efforts of time and water, and often to those of man. We have, therefore, thought that it would be of interest to give here a description and view of some of these ancient bridges, so that the very characteristic differences between such structures and those of our present type may at once be seen.

The bridges of ancient Rome at the imperial epoch were seven in number, and may be classified in the following order, from the viewpoint of the date of construction: Sublicius, Æmilius, Milvius, Fabricius et Cestius, Triumphalis, Janiculensis, and Ælius. We deal here more especially with the Sublicius, Fabricius, and Ælius Bridges, which constitute the most curious models of this type of construction. We shall afterward remark upon the Salarius Bridge, situated outside of the city, but presenting a certain interest.

The Sublicius Bridge, the first one constructed over the Tiber, connected the Forum Boarium with the Transtiberian wards. It was constructed during the reign of Ancus Martius, and was of framework, with a foundation upon piles. The legendary defense of Horatius Cocles against Porsenna gave it a celebrity that associated it with the beginning of the history of Rome; but, after the war, it was rebuilt of wood assembled with simple iron bolts, which thenceforward permitted it to be more rapidly taken apart in case of an unexpected attack.

Its maintenance was then intrusted to the pontifices, without whose authority it was forbidden to repair it. This bridge was carried away later on by a rising of the water of the Tibar, and was reconstructed of stone by Æmilius Lepidus, who was the last censor under Augustus.

Afterward, however, it was again damaged by floods in the Tiber, and was finally carried away in the year 780 of our era and completely destroyed. The Fabricius Bridge (Figs. 2 and 3) connects Tiberine Island with the left shore of the Tiber, and is prolonged to the Transtevere by the Cestius Bridge. It was constructed in the year 733 of Rome by Reius Fabricius, curator viarum, as shown by the ancient inscriptions preserved under the arcades of the bridge. In fact, we read on one of the arch keys:

L. FABRICIUS CF. CVR. VIAR.
FACIUNDUM CŒRAVIT.

And upon the other:

IDEMQUE PROBAVIT
Q. LEPIDUS, M. F. LOLLIUS, M. F. COS.
EX. S. C. PROBAVERUNT.

This bridge, of which a view is given in Figs. 2 and 3, is, along with the Ælius Bridge, the one that best represents the type of Roman architecture. It is 250 feet in length and comprises two arches, one of 79·5 and the other of 80 feet opening. These arches are supported by two land abutments and a central pier 33 feet in thickness at the springing of the arches.

A small arch of 13 feet opening reduces the thickness of each of the abutments and another of 16 feet crowns the pier. The thickness of the arches is 6 feet. The top walls are surmounted by plinths and cornices supporting a coping with sunken panels. As may be seen, the line of these cornices remains sensibly horizontal between the keys of the two arches—a feature that gives a more satisfactory aspect than does the shelving arrangement that is generally observed upon works of subsequent construction. The width is 19 feet between the outside faces.

The Ælius Bridge (Fig. 1), which is regarded as one of the most remarkable of Roman architecture, was constructed in the year 136 of our era by Emperor Ælius Trajan Adrian, in order to give access to the mausoleum which bears his name, and which in our day has become the Saint Ange Castle. In its original state it was formed of eight semicircular arches, of which three in the center were of the same dimensions, while three others decreased toward the left shore and two decreased toward the right. The extreme arches that served simply to allow of the flow of the high water were, however, subsequently buried by the filling in of the quays, and the bridge was thus reduced to five arches only, as shown in Fig. 1.

The primitive arrangement, the remembrance of which had been lost, was rediscovered only through the excavations made on the occasion of the recent enlargement of the bridge. In the sketch shown the bridge has a width of 33·5 feet and a total length of 346. Its height above low water mark must have been 50 feet. The central arches have an opening of 59 feet and are supported by piers spaced 82 feet from axis to axis, and having a width of 21·5 feet and a length of from 65 to 75. They are constructed of travertin, with retreating courses 32 inches in height. At the level of low water they present a starling on the upstream side and a square mass of stone on the downstream side. At the time of enlarging the bridge the ground was cleared away in order to establish a stairway, and in this way were discovered upon the left bank the two arches mentioned above.

These arches, which were in a perfect state of preservation, had a uniform width of 10 feet, and their foundation rested upon a floor of concrete (Fig. 4). Three soundings were made in order to ascertain the strength of the masonry of the abutments, as well as the exact depth, and to find out whether or not a platform existed under the large arches. The first sounding was under the abutment to the left, and showed that the masonry was formed of layers of blocks of travertin and tufa with cemented fragments of basalt, and descended to a depth of 15·25 feet beneath low water. The second sounding, made under the starling of the first pier to the right, showed that the masonry descended at this point to the depth of 34·25 feet beneath low water (Fig. 5).

A third sounding made in the bed of the river to a depth of 49·5 feet beneath low water in the axis of the first large arch to the right, did not reveal the presence of any platform, and there is, therefore, reason to conclude that the bridge had none in the bed of the river.

Among the bridges situated outside of Rome, and which by their upstream position were capable of having an influence upon floods, we may mention particularly the Salarius Bridge over the Anio (Teverone), the view of which, reproduced in Figs. 6 and 7, furnishes a particularly striking example of the obstructions that attended such works.

This bridge, rebuilt by Narses in the sixth century upon the site of the ancient bridge that had rendered Manlius Torquatus illustrious, comprised a central arch of 87·75 feet, the springings of which surmounted two banquets that had a projection of 6·5 feet and narrowed the minor bed to 74·5 feet. The abutments themselves were provided with two lateral arches, each of which had an opening of 14 feet. The width between the external faces was 27·75 feet. The roadway ascended by gradients of one inch to the foot to reach, at the summit, a height of 50·5 feet above the springings of the arches.

In a passage reproduced by M. Ronna, Engineer Leger, in giving a description of the Ælius Bridge, adds that the latter seems to mark the beginning of a decadence in ancient art.

For the above particulars and the illustrations we are indebted to La Nature.

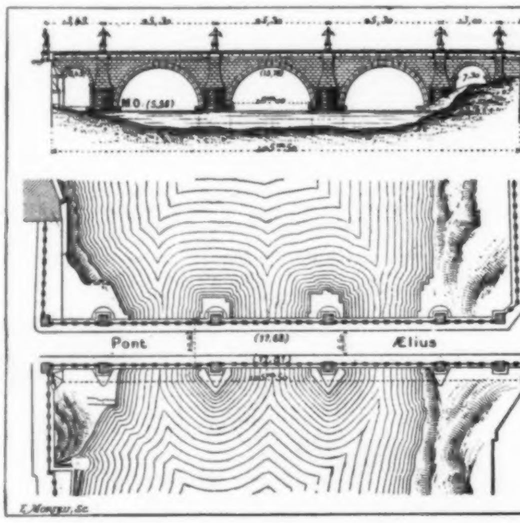


FIG. 1.—ELEVATION AND PLAN OF THE ÆLIUS BRIDGE. PRIMITIVE STATE BEFORE ENLARGEMENT.

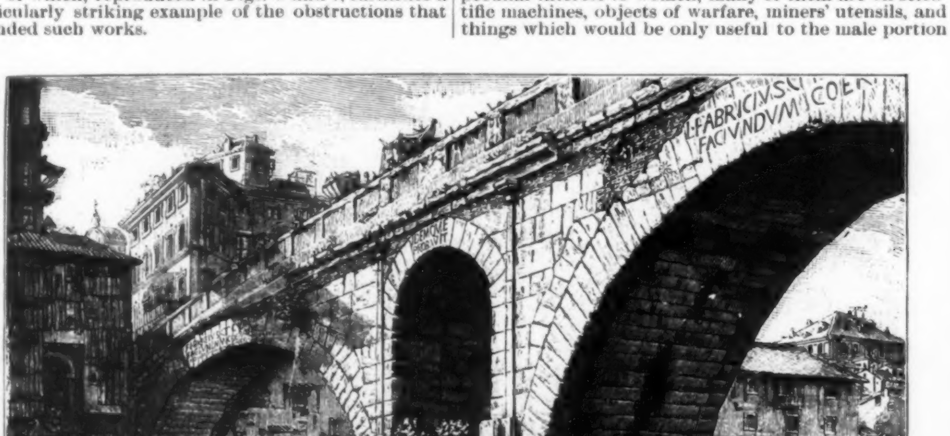


FIG. 2.—FABRICIUS BRIDGE. (REDUCTION FROM AN ENGRAVING BY PYRANESI.)

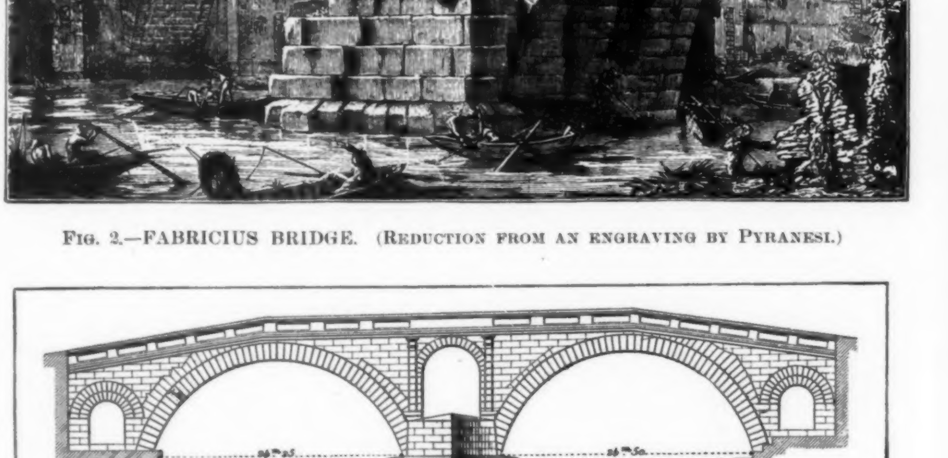


FIG. 3.—ELEVATION OF THE FABRICIUS BRIDGE.

WOMEN INVENTORS.

ASSISTANT Chief Alexander Scott, of the division of drafting of the Patent Office, has an interesting list of the patents granted to women inventors of the United States, compiled from 1790 to January 1, 1895. Up to that period there had been issued 531,618 patents to all persons, the number of women included being surprisingly large, says The Washington Evening Star.

The articles on which the patents have been granted comprise everything in the patentable line, from a curling iron to a cooking stove, and from a war vessel to a handsaw. While many of the patents are on objects of peculiar interest to women, many of them are on scientific machines, objects of warfare, miners' utensils, and things which would be only useful to the male portion

of humanity. Of course, the baby has not been forgotten, and the articles patented to make the "mother's joy" more comfortable and contented form a department all to themselves. Collar buttons have been invented by wives, mothers, and sweethearts. Evidently this was done to ease the masculine mind or prevent the accustomed, or, at least, accredited, profanity which is supposed to flow when one of the buttons becomes detached from a garment and rolls somewhere out of reach or "cannot possibly be found."

COMPLIMENTARY COMMENT.

"We have found," said Mr. Scott to The Star reporter, "that the objects patented by women are of just as practicable a nature as those got out by the men. Very often it happens that men invent an object which is of interest exclusively to womankind, as a new style of hair fixer, but the reverse is often the case. It frequently happens that a woman will suggest something to her husband, or some male member of the family, who acts upon it, taking out the patent and getting credit for it, of course, fully with the consent of the one suggesting the idea. Any one who thinks that a woman is incapable of inventing anything really useful is making a great mistake, as a look over the list of the thousands of objects will testify. Some of the most important things in use nowadays have been invented by women and brought into general use by them."

The first patent issued to a woman, according to the list, was given to Mary Kies, whose address has been lost, owing to the fire which occurred in the Patent Office in 1836. It was granted May 5, 1809, and was for straw weaving with silk or thread. The next was to Mary Brush, and was granted July 21, 1815. This was essentially for a woman's article—a corset, of which there are more patents issued to women inventors than for any other article. The next was to Sophia Usher, September 11, 1819, and was for cream of tartar, carbonated liquid, so it can be seen that "baking powders" were discovered at an early date comparatively in the nation's history.

July 10, 1840, Marie F. C. D. Corbaux, Francis G. Spilsbury, and A. S. Byrne took out the patent for "improvement in the mode of applying distemper colors, having albumen or gelatine for their vehicle, so as to render the same more durable, and preserving the same when not wanted for immediate use." As can be seen, this invention was of purely a scientific nature.

The corset invented by Mary Brush in 1815 must have pretty well filled the bill, for a number of years at least, as there is no other invented, at any rate by a woman, until January 21, 1841, when a patent was taken out by Elizabeth Adams.

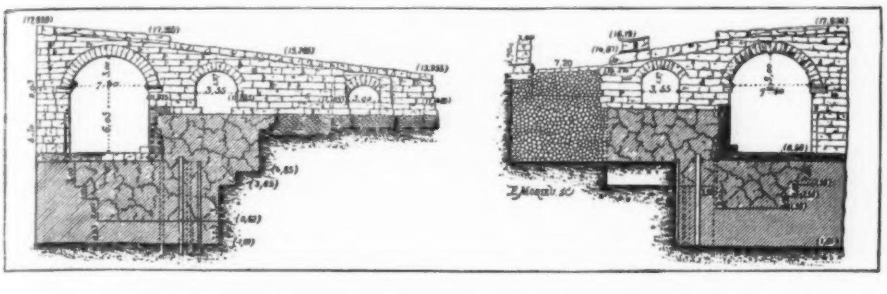


FIG. 4.—ÆLIUS BRIDGE—RIGHT AND LEFT APPROACHES.

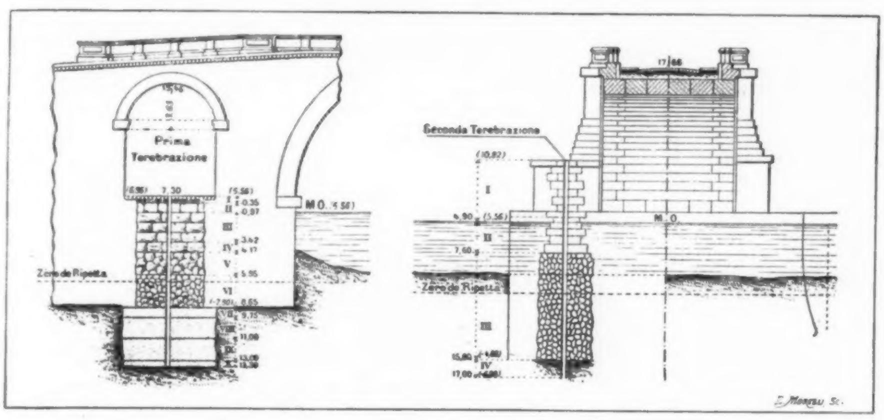


FIG. 5.—ÆLIUS BRIDGE—LEFT ABUTMENT AND FIRST PIER TO THE RIGHT.

FIG. 6.—SALARIUS BRIDGE. (REDUCTION OF AN ENGRAVING BY PYRANESI.)

FIG. 7.—ELEVATION OF THE SALARIUS BRIDGE.

Nancy M. Johnson in 1843 invented an ice cream freezer, and Sarah P. Mather in April, 1845, a submarine telescope and lamp. Madeline Tassie took out a patent on a shirt in 1847. Mary Ann Woodward had a notion of combining ease with dignity, for April 24, 1849, she took out a patent for a rocking chair, with fan attachment. Susan E. Taylor, East Cambridge, Mass., June 20, 1858, received a patent for a fountain pen. It is not only the people of the present day, it may be well to observe at this point, who have their troubles.

Elizabeth M. Smith, of Burlington, N. J., was evidently of a practical turn of mind, for August 7, 1860, she took out a patent for improvement in reaping and mowing machines. Sarah Jane Wheeler, New Britain, Conn., January 22, 1861, received a patent for a currycomb. The spirit of approaching war time is shown in only two cases. These are those of a patent for a bandage, taken out by Martha Willis, Rochester, N.Y., March 26, 1861, and May 23, 1865. Sarah J. A. Hussey, Cornwall, N. Y., received a patent for a hospital table. During the war a number of patents were granted women for corsets and domestic articles.

Mary Jane Montgomery, New York city, was granted a patent May 31, 1864, for improvement in locomotive wheels. Elizabeth A. Burns, Meadow Lake, Cal., March 8, 1870, took out a patent for an improvement in desulphurizing ores. Carrie R. Laman, Painted Post N. Y., April 25, 1871, received a patent for improvement in lubricating railway journals, and Augusta M. Rodgers, Brooklyn, N. Y., May 9, 1871, one for improvement in conveyers of smoke and cinders for locomotives. Martha J. Coston, of Washington, June 13, 1871, received a patent for an improvement in pyrotechnic night signals.

Harriet Z. Gill and A. V. Coale, of Pittsburg, February 27, 1872, were granted a patent for improvement in cosmetic compounds, and Sally M. McNett, Topeka, Kan., March 26, 1872, made an improvement in hair restoratives, for which she was given a patent. Jane Mary Innes, Council Bluffs, Iowa, June 11, 1872, was granted an improvement for cigars, and Harriet H. May, Birmingham, Conn., June 25, 1872, was granted a patent on an improvement for bustles. Mary E. Walton, New York city, February 8, 1881, was granted a patent for an elevated railway. Harriet W. Strong, Los Angeles, Cal., December 6, 1887, was granted a patent for dam and reservoir construction.

CONFINED TO CULINARY DEPARTMENT.

The majority of the patents issued to women of late years has been for articles in the culinary utensil line or that of furniture and furnishings, while in regard to wearing apparel there have been many patents. It rested with Henrietta J. Lyon, Newark, N. J., to invent a waistband for trousers, for which a patent was issued January 2, 1894, and for Leah D. Jones, New Berne, N. C., to take out a patent for pantaloons protector, May 8, 1894.

There have been a number of typewriter patents issued to women inventors, sewing and spinning machines, stationery articles, toys and games, toilet articles, musical apparatus, theatrical appliances, medical appliances, and agricultural implements. Probably one of the most amusing patents for an invention is that of an improvement on a hammock for two.

If the new woman wishes some object lesson to prove that the mind feminine is not a whit behind that of the male, she can point proudly to the list of women inventors in the Patent Office. But if the argument needs to be refuted, it can be done so successfully, it is claimed, by pointing to the fact that many of the articles invented are solely to gratify woman's vanity and assist in the adornment of her physical charms.

That, however, this desire is not confined solely to woman is shown in one case, that of a woman of Oakland, Cal., who invented a mustache guard so that the hirsute adornment of the lip of man should not be disfigured.

KIESELGUHR AND OTHER INFUSORIAL EARTHS.*

INFUSORIAL earths having recently come into request by pharmacists, and being very diverse among themselves, as well as suitable for a variety of purposes, it may be useful to collect leading facts of special interest concerning them, and to indicate particular applications of which they are susceptible. That is all this short paper professes to do.

Kieselguhr is the German name for an infusorial earth which is found in Hanover. It means siliceous deposit, and aptly defines a geological formation consisting of the minute fossil shields of diatoms, which is nearly pure silica in those parts nearer the surface, while in others lower down it is contaminated with more or less organic matter. In Hanover the deposit is 150 feet thick from the surface downward. The upper stratum is nearly white, with very little organic matter; lower down it is gray, with very little sand but more organic matter. The lowest and thickest stratum is, according to Thorpe, from 50 feet to 100 feet thick, and contains up to 30 per cent. of organic matter. We might argue from these facts that a process of oxidation goes on in the upper stratum, which changes the nature of the organic matter, rendering it more soluble and less colored. A sudden rainfall would effectively wash this stratum, carrying the organic matter downward to the lower stratum, which, being charged with air to an inferior degree, is less capable of assisting change; indeed, it would seem to have the power of preventing it; hence the accumulation of green color and organic matter, which are said to be due to extractive from the pine needles strewing the surface of the earth above the deposit. This organic matter, together with the color, is got rid of by calcining in small furnaces, which are filled with the kieselguhr and then lighted at the bottom. The organic matter suffices to keep the whole in a glow like peat, and the process is made continuous by raking out below and supplying fresh material at the top. The calcined process consists almost exclusively of silica, and varies from very pale cream to a reddish color, according to the proportion of ferric oxide present. Beckerhinn found 95 per cent. of SiO_2 and a specific

* By John Moss, F.I.C., F.C.S. A paper read at the British Pharmaceutical Conference, held at Belfast, August, 1898.—English Mechanic.

heat of 0·2089. The strongest acids have, of course, no action upon it, but with alkalies it fuses easily, and a variety of soluble glass may be made in this way.

In France there occurs a similar siliceous earth called randanite (from Randan, in the Puy de Dome).

Other deposits are found in Scotland, near Aberdeen, and in the island of Mull; in Norway, where it is called bergmehl; under the city of Richmond, in Virginia, in the Bermudas, in Australia, in Algeria, in North Wales, at South Mourne, and in many other parts of the earth.

Infusorial earth consists of the siliceous envelope of Diatomaceæ, a family of minute uni-cellular plants, also called "brittleworts," from the facility with which they may be cut or broken through. The siliceous envelopes, or diatoms, as they are commonly called, are usually of the most perfect symmetry, and often exhibit elaborately marked patterns of great delicacy, which endow them with extreme interest as microscopic objects. The forms may be simple or intricate, but all are beautiful. There are few objects so attractive to the microscopist as the minute siliceous framework of these low forms of plant life, and many hundreds of different varieties have been catalogued.

Having regard to the origin of these deposits, diatomite would seem to be a name generally appropriate, and I purpose using it in this sense, as including all the varieties of siliceous earth above referred to. I cannot hope to name every kind of diatom which has contributed to form each one of the deposits, but having examined several microscopically, I may succeed in enumerating some of the more important individuals.

1. Kieselguhr.—In this the forms recognized are Surirella, Gaillonella, Diadesmis, Pleurosigma, Synedra, Stephanodiscus, Spongolithis, Amphora, Melosira, and Navicula.

2. Scotch Diatomite.—This occurs in the island of Mull and near Aberdeen, and includes among other forms, Diatom Cymatopleura, Synedra, Gomphonema, Coconema, Surirella, Primularia, and Rhabdonema.

3. Virginian.—A stratum 18 feet thick underlies the whole city of Richmond, extending, indeed, over an indefinite and unknown area. It is so compact as to be capable of being carved into small objects, such as the bowls of tobacco pipes, but is at the same time light and friable. It is celebrated for the number and beauty of its forms, including Coscinodiscus, Dictyolampa, Rhabdonema, and Triceratum.

4. Australasian.—According to Dr. J. D. Hooker, there is a deposit consisting chiefly of the siliceous loricæ of Diatomaceæ, not less than 400 miles long and 120 miles broad, at a depth of 200 feet to 400 feet on the flanks of Victoria Land, in 70° south latitude.

5. Scandinavian.—This is known locally as bergmehl, or mountain flour, and contains sufficient organic matter to occasion it in times of scarcity to be mixed with dough in making bread. I have seen no specimens of this, and am unable to describe its appearance, or to name any diatom occurring in it.

6. Australian.—This is a beautiful white fluffy powder, of which specimens came into my hands in 1894, through the kindness of the South Australian government and others. It consists almost solely of the loricæ of Tetarcyclus, with occasional Pleurosigma, Surirella, Amphora, and Diatoma. There is ground for assuming that this and the Australasian deposit referred to above (which I have not seen) are the same.

The examination of eight different specimens of infusorial earth obtained from as many different sources shows important variations in composition. In no case does the silica (SiO_2) exceed 96 per cent. and it falls as low as 70 per cent., the differences being made up by moisture, organic matter, ferric oxide, and alumina. Moisture varies from 2·64 to 7·8 per cent., the average being 5·73 per cent. Organic matter ranges from 2·43 to 23·6, giving an average of 7·43 per cent. Of the professedly calcined earth, I have met with specimens containing so little as 0·4 per cent. of organic matter, but the proportion usually present is from 2·5 to 3 per cent., showing that the calcining is not perfect. Again, in some earths the iron oxide is as much as 25 per cent. and in others it is as low as 7 per cent.

USES.

Since 1866 diatomite has been largely used in the manufacture of dynamite. This is because it is capable of absorbing a larger proportion of fluid than any other known material that is at all available to the same extent. It will absorb three times its own weight of nitroglycerine, and then be capable of being pressed into solid blocks.

It is also used to make so-called "dry sulphuric acid." One part of diatomite to three or four parts oil of vitriol by weight may be mixed so as to form a mobile powder capable of being worked with iron implements and inclosed in iron drums for export without attacking the metal. I am informed that the success of this expedient is not yet fully assured.

A very important demand for diatomite is for a basis for disinfecting powder, to make which it is charged with 10 or 20 per cent. of carbolic acid or other liquid disinfectant. Such a powder is much lighter than are those with chalk or lime as a basis, and possesses the advantage of floating on the surface of any liquid upon which it is sprinkled, so that what effluvium arises must pass through the disinfectant. The crudest forms are suitable for this purpose, and 1 pound occupies the bulk of 3 pounds of chalk.

Another very important application of diatomite is found in the ease and perfection with which metals may be polished by its means, either in the form of powder or of a paste made with as oft paraffin. For this purpose grit of all kinds must, of course, be carefully removed, leaving a powder of such a degree of fineness as not to scratch gold plate, yet impart a very high polish to it.

I have used diatomite associated with sodium silicate and fibrous material, such as a cow hair, for making an adherent covering for steam boilers, pipes, and pans. Loss of heat by radiation being prevented, there is a corresponding economy of fuel, and the temperature of the laboratory is moderated, to the great comfort of those who work in it.

Safe makers take advantage of its non-conductivity in the construction of fire-proof chambers. This property makes it valuable also in the construction of ice houses, and, indeed, wherever it is desirable to prevent too great loss or accession of heat.

Diatomite is said to find its way even into soap, and there is no doubt of its employment in the manufacture of ultramarine and of artificial meerschaum.

Its non-conductivity is not confined to the heat wave. It effectually smothers other undulations, and is therefore equally useful for making walls sound proof, so that the inmates of a classroom in a musical seminary may practice without disturbing or being disturbed by similar students in the next chamber.

The properties of diatomite above indicated are naturally suggestive of certain uses in pharmacy. For some of these the absence of gritty particles is absolutely necessary, and freedom from organic matter is desirable for all.

AS A FILTERING MEDIUM.

My attention was first attracted to diatomite for this use. Provided it were possible to obtain or prepare it free from organic matter, it seemed to possess all needful qualities for filtering liquid galenicals and certain solutions of salts and acids. Silica has powers of resistance to solvents far greater than the filtering powders in common use, viz., the carbonates of lime and magnesia, phosphate and sulphate of lime, talc, and asbestos. All these, being compounds, are susceptible of decomposition; indeed, the four first mentioned are of more than doubtful utility, and should be banished from the laboratory for purely filtering purposes. Diatomite, which may be regarded as pure silica, is absolutely indifferent to all but the strongest alkalies at a high temperature—involving a set of conditions which the pharmacist does not have to consider. There is the further advantage that it does not clog up the filtering bag to the same degree as either talc or asbestos, and filtration is consequently more rapid. The benefit of this is not confined to the manufacturer, who is thus able to accomplish more work in the same time; but what is of greater importance, it extends to the preparation also, which must be better for less handling and exposure. This is not secured at any sacrifice of efficiency. Note may be made of a practical point here. Diatomite does not mix readily with liquids, and should not be dusted on the inner sides of the filter bag in the expectation that it will diffuse through the liquid which is afterward poured in: nor can it be satisfactorily mixed with the bulk of the liquid. It should be worked down in a mortar with a little of the liquid to be filtered, so as to form a smooth, thin paste, which can then be mixed with more of the liquid to set the filter. This takes place almost at once, and but little of the filtrate requires to be returned. Inattention to this point has occasionally caused failure with diatomite as a filtering medium.

Small though the particles of diatomite may be, they appear to be large enough, and to present irregularity enough, to keep apart the particles of albuminoid or starchy deposit, sufficiently for the passage of the still smaller particles of liquid. It is obvious that the diatomite used for filtering must be free from organic matter—a few particles of sand may be disregarded.

DENTIFRICES.

For making these, diatomite must be free from sand and also from organic matter, which is apt to suggest a disagreeable, earthy taste. It should be as white as possible, so as to exclude interference with the tint of the ingredients. These conditions secured, it may with advantage take the place of ground pumice and cuttlefish bone in all cases, and of precipitated chalk in paste and powders which contain other alkaline bodies, such as bicarbonate of soda and borax. If no alkali is present, or if diatomite alone is considered too light, some chalk may be retained in a powdered dentifrice with benefit. Diatomite properly refined is not gritty between the teeth, and polishes without scratching the enamel. Bulk for bulk, it is half the weight of the lightest precipitated chalk. The formulæ appended are merely suggestions as to the proportions in which diatomite may be used in dentifrices, and are, of course, susceptible of an infinity of variation, according to taste and experience:

Diatomite Tooth Powder.		Diatomite Tooth Paste.	
Diatomite	1 oz.	Diatomite	1½ oz.
Creta præcip.	1 oz.	Alum. ust.	½ oz.
P. sapo. alb	1 oz.	P. myrrhæ	¼ oz.
Otto rosæ	m ij	Ol. caryoph.	m vj
Ol. caryoph.	m j	Glycerin	½ oz.
Ess. menth. pip.	m v	Ex. cocci liq.	q. s.
Sacch. lact.	1 dr.	M.S.A.	

DUSTING POWDERS.

By virtue of its enormous and unequaled absorbent property diatomite is unrivaled as a dusting powder basis. It must be the very purest that can be produced, and when absolutely free from organic matter and grit is more smooth and less irritating than any other powder. Unlike vegetable powders, it does not contribute to decomposition of the exudation, but keeps sweet for a long time, and may, of course, be associated with antiseptics with equal facility and greater advantage. Smoothness is imparted by the addition of boric acid in very fine powder. Oxide of zinc, kaolin, talc, or fuller's earth may be added according to circumstances and the object aimed at, as also such antiseptics as salicylic acid, iodoform, thymol, etc. Diatomite as a polisher of metals has already been referred to, and it only remains to say of it in this connection that it is obtainable of all degrees of fineness, suitable for fire irons and fenders at one end of the scale and for the finest gold plate at the other.

IN DISPENSING.

The last suggestion I have to make relative to the use of diatomite in pharmacy is perhaps more debatable than any of the preceding. I mean as a diluent for hygroscopic powders, such as euonymin when made by the late pharmacopœia process. However carefully this may be prepared according to the official directions, it presents difficulties which are more or less great with different batches of the drug. Being absolutely inert and insoluble in the stomach juices, diatomite cannot react on the drug as chemical powders like magnesia may, and the mixture is much more easily reduced to powder than when sugar of milk is used; it also remains pulverulent. On the other hand, the question arises as to how far it is advisable to introduce silica, however finely divided, in the stomach. The quantity at most is a few grains, and may be less than one grain, and when it is remembered that at times of scarcity or famine the Norwegian peasantry have been compelled to eat ounces and even pounds in one week, the doubt is deprived of much of its significance. Further, whole meal bread is recommended and largely consumed for the wholesome action of the siliceous particles (much coarser than diatomite) in the grain husk on the intestinal canal, so that it would seem as if only beneficial effects would be produced by the minute proportion in a dose of euonymin or similar remedy, whether given in the form of a powder or of a tablet. The binding power of diatomite under pressure suggests its use in the last mentioned form for drugs which compress with difficulty.

DRABA OLYMPICA HETEROCOMA (NATURAL SIZE).

DRABA OLYMPICA VAR. HETEROCOMA.

THIS is a pretty little Draba of tufted habit, with linear, erect, glabrous leaves, and spikes of golden yellow flowers. It is a native of Anatolia and other parts of the Levant. Our illustration, for which we are indebted to Mr. Siehe, of Mersina, shows a plant growing under natural conditions.—The Gardeners' Chronicle.

ENGINEERING NOTES.

The first automobile express truck ever made is now on public exhibition in Chicago. It weighs 9,000 pounds net, and its carrying capacity is between five and six tons. The truck has scaled the Twelfth Street viaduct, the steepest in the city, with the greatest ease, notwithstanding a load of three tons or more.

A new railway from Germany to Italy is, we hear, in contemplation. The line is to be called the Vintschgau Railway, and is to start from Landeck, on the famous Arlberg line, and to continue through the Vintschgau Valley, by Reschenscheideck, Meran, Trafoi, and Bormio, to Milan. Apart from the benefit which would accrue to the German export trade from what would be the shortest route from North Germany to Italy, the railway would be one of the finest Alpine lines in the world, as it would lead through the Ortler Mountain groups, and traverse the famous Stilfeserjoch, the highest road in Europe, through a tunnel 7,500 meters long, while the St. Gothard tunnel is over 14,500 meters.

Portland cement plays such an important part in the formation of concrete for buildings or foundations that it is highly desirable to have a certain method of testing its quality and capabilities. An association has now been formed for the purpose of testing Portland cement under standard conditions. The general offices are 136 Shaftesbury Avenue, London, and Mr. Edmund B. Spencer, B.Sc., is the general secretary. There are a certain number of regular subscribers, but the association will undertake to make tests and issue reports to any members of the public. The association has issued a small pamphlet, in which the absence of generally accepted and uniform conditions of cement testing is commented upon, and reference is made to the need of adequate tests of this material.

Track elevation in Chicago has made considerable progress during the past year, as shown by the annual report of Mr. John O'Neil, superintendent of track elevation. From this report we take the following summary:

Track elevated during 1898	16·2 miles.
Track previously elevated	19·0 "
Total track elevated to December 31, 1898	35·2 "
Track yet to be elevated	14·3 "
Total track elevation provided for	49·5 "
Grade crossings eliminated during 1898	95
" " previous to 1898	86
" " yet to be eliminated	88
Total number of grade crossings provided for	249
Cost of work done during 1898	$6,650,000
Cost of work completed to December 31, 1898	12,700,000
Cost of work yet to be done	4,230,000
Total estimated cost	16,930,000

—Engineering News.

The design and construction of a thrust block or bearing has so much to do with the successful working or otherwise of a marine engine that too much consideration can hardly be given to this important detail. There are two principal types of thrust blocks—the ring or collar bearing, and the horseshoe bearing. The former is largely used in the navy, as it has a large area of bearing surface per pound pressure of thrust, and it is much shorter than the other type for the same surface. The ring does well so long as there is no heating, but when it gets out of order it is difficult to adjust at sea. The horseshoe type, though longer and heavier, is more accessible and easier to handle. Each horseshoe is capable of adjustment, and the open space permits of easy examination, and of the access of air to exercise a cooling effect on the bearing. Some good working drawings of both types of bearing are given by Mr. William Burlingham, in the December number of Machinery, and these are well worthy of careful study by the young engineer. The formulæ for calculating the thrust pressure and principal dimensions are simple and intelligible, and will be regarded as useful data by the marine engine draughtsman. The writer concludes a good practical description of the best modern practice in regard to this particular by advising all designers to make the thrust pressure low, the oiling grooves large, the bolt stresses low, and the bearing surfaces of the best white metal procurable. There should also be provision for water service, tap for lifting bolts in every piece that has to be lifted, and large starting screws should be used wherever there are two surfaces bolted together.

It need hardly be wondered at that a mountain railway should be used for a toboggan slide, for it is just the idea that would strike the average school-boy if the means of utilizing the incline could be shown to him. An illustration is given in a contemporary of the application of a toboggan slide on the Manitou and Pike's Peak Railway. The use of this device is, of course, limited to the officials and employés of the railway. The vehicle, which is placed on the rack rail, consists essentially of a plank 3 feet long by 12 inches wide. Along the middle of the underside a cleat fits between the rack bars and so keeps the toboggan from shifting sideways. On either side of the rack bars are brake-shoes which can be brought into clamping action against the sides of the rack. The brake is operated by a lever which the rider holds within his grasp. To prevent undue wear of the plank where it bears on the top of the rack, there are strips of steel secured to the lower side, and to keep the slide from capsizing, a bar of iron extends on both sides to rest on the top of the ordinary rails, bearing and sliding on the smooth surface all the way. The front end of the plank has a rest for the rider's feet. The rider has simply to sit upon the toboggan and hold the brake lever in his hands to regulate the speed of descent. This may be as rapid or as slow as the rider pleases. The entire track from the top of the Peak to Manitou is nine miles, and the average incline is 845 feet per mile. On one occasion an employé of the company made the entire trip over the nine miles in eleven minutes, which is not far short of a mile a minute. Although the rack is lubricated with soap, it is said that at high speed a stream of fire flashes in the wake of the slide.

ELECTRICAL NOTES.

An edict has been issued to the effect that all Russian railway carriages must be lighted by electricity by means of a separate accumulator for every carriage. First class compartments will be lighted by 100 candle power lamps; second class by 80 candle power, and third class by 50 candle power lights. In every compartment stearine candles must be also supplied in case the electric light refuses to act.

The Westinghouse Electric and Manufacturing Company, in Pittsburg, has taken orders for fourteen cars and other electric equipment for a street railroad in the city of Cairo, in Egypt. It is proposed, in connection with this road, to build a line from Cairo to the Pyramids, and later another from Cairo to Alexandria. The Schoen Pressed Steel Company, in Pittsburg, has an order for 400 steel cars for the Soudan Railroad.

An electrified bridge which recently shocked a number of men and horses in Chicago is stated by Mr. A. G. Riter, city bridge engineer, to have received its charge from a broken live wire. This came in contact with the ironwork of a draw-span, which transmitted the current to wet woodwork, and in this way caused the trouble. The structure was what is known as the Harrison Street bridge, and while the electricity wandered about for a short time only, it caused enough annoyance to show the importance of preventing such currents from straying.

Steam power is going out of use in small plants in Philadelphia, Pa., owing to the substitution of electric power generated in large central stations. According to the annual report of Mr. John Overn, chief of the bureau of engines and boilers, in Philadelphia, 625 boilers are located in place but are "temporarily out of use" out of a total of 3,579 boilers under the supervision of the bureau; the larger number out of use being due chiefly to the substitution of electric power. During the year 1898, 306 new boilers of different styles were erected in the city as follows: Horizontal tubular, 112; compound tubular, 9; vertical tubular, 115; locomotive, 9; sectional, 46; patent boilers, 17. No explosion of a steam boiler occurred in the city during the year, but two serious accidents occurred to steam piping used in connection with engines and boilers, each involving loss of life.

In some of the German collieries, and especially the Mont Cenis colliery in the West Dortmund district, excellent results have been obtained in shot firing with a magneto-electric machine and wire cables of a most primitive character; for example, the conductor from the machine to the shot in dry mines consists of nothing but a galvanized iron wire 0·039 of an inch thick for dry workings and insulated copper wire for wet ones. For insulation, the conductors for the current from the firing station to the shot are supported loosely in eyes cut in the side timbers. Misfires with these machines are very few in number; for example, in firing 1,663 shots no misfires occurred. In another case, 548 misfires occurred out of the great total of 34,274 shots, or the misfires were in the ratio of 1·16 per cent. The cost of firing a shot in this way was found to be 3 cents, against 1½ cents for ordinary firing with safety fuses.—Zeitschrift für Berg-, Hütten und Salinen Wesen.

One of the complaints, but not always just, in regard to a policeman is that you can never find him when he is wanted. Many measures have been taken to remedy this state of affairs, and resort has been made to the telephone signaling system, etc. Ex-Chief McCullagh, of the police force of Greater New York, who was in the service for thirty years, has studied this problem carefully, and has evolved a system of communication which marks a new departure in the police supervision of any large community. He proposes to establish a certain number of policemen at stated points all over the city, connecting their booths, or sentry boxes, by telephone with the police station of the precinct. No matter what happens, any one who wants the help of the police can go at once to these well known points and obtain the services of the officer there, he, in turn, notifying his headquarters of the call, and securing a relay, in the shape of one officer or a dozen, as the case may need. It will be obvious that such a system not only gives instantaneous police help, but by establishing a series of "trochas," makes it very hard for a fugitive criminal to break through, as he is liable to interception in whichever direction he goes. One of these interesting booths was on exhibition at the Electrical Exposition last May, and the city of New York has recently made an appropriation to help carry out this McCullagh system.—Electrical Review.

To what extent electric railways have been developed in the United States, where, admittedly, they have prospered in a manner unparalleled elsewhere, is shown in a short chapter of statistics given in the annual report of 1897 of the United States Commissioner of Patents. The first electric street railway in the United States was put in operation only a little more than ten years ago. In 1880, of the 2,050 road miles of street railway in the country, nearly all employed animal power. Electric power had not yet come into use, but a few miles of lines were operated by steam and by cable. The total number of persons then employed on American street railways was a few hundred short of 12,000. Ten years later, in 1890, the United States census gave the number of street railway employés at 37,434, and at the close of that year the total mileage of street railways all over the country was given as 8,123 track miles, on 5,661 of which horses were used, while the remaining 2,462 miles were worked mainly by electric and cable power. The capital invested in these roads was $211,277,793, and 71,000 persons were employed on them. In 1894 the total mileage was 12,527, of which 7,470 was electric. The capital invested was $648,330,755, of which $423,493,219 were invested in electric railways. One hundred and ten thousand persons were employed on street railways in that year. In 1896 the mileage had increased to 14,470, of which 12,133 miles were electric. The capital invested was $784,813,781, and the number of persons employed was not less than 140,000. The total mileage of electric railways in the United States up to October, 1897, was 13,765 miles, out of a total mileage of 15,718, and of these but 947 miles were horse car lines. The total capital invested was $846,131,691, and the number of employés may be safely estimated at not less than 166,000.—Cassier's Magazine.

SELECTED FORMULÆ.

The Preventive Treatment of Baldness.—Basing his treatment on the fact that the hair contains a substance similar to glue and gelatine, Dr. Deichler has administered colloids, in different forms, in different affections of the hair (La Med. Moderne). Together with a tonic régime, he gave the patients bouillons prepared by prolonged boiling of two parts of meat and one part of bones. The bones were frequently replaced by gelatine, or by shavings of deer's horns, which are very rich in ossifying cartilage. The favorable effect of this treatment is seen first of all in old men; with the improvement in the general condition there is an increased elasticity, a kind of rejuvenation of the skin; there was also a certain diminution in the rigidity of the arteries (which fact induced the author to try the treatment in arterio-sclerosis). In younger persons the action of the colloids showed itself upon the hair very distinctly. The thin hairs became firmer, they acquired a brilliant luster, the falling of the hair ceased. This favorable influence showed itself in the hair all over the body. The nails also became more brilliant and transparent. Systematically used, this treatment will go far to prevent baldness. At the same time, the hair should be well taken care of, and one of the best ways to do it is to wash it frequently with soap and water.

Stains for Dyeing Wood Various Colors.—

Pink.—Make two baths, one a solution of 2 pounds of potassium iodide in 2½ gallons of water, and the second a solution of 1 pound of corrosive sublimate (bichloride of mercury) in 4 gallons of water. After the wood has been immersed in the first bath for some hours transfer it to the second, and keep it there till the proper color is reached. The dye will be very rich and uniform.

Red.—(a) Treat the wood first with a solution of Marseilles soap (one part of soap in forty parts of water), and then with aniline red.

(b) A very fast red is imparted to cherry wood by permanganate of potash. When the wood has been stained, wash and dry it, and polish it with oil.

(c) Boil 1 pound of finely powdered cochineal in 2 gallons of water for three hours, and then rub it into the wood. When the surface is dry apply to it a mordant containing one part of tartaric acid and two parts of tin salt (tin protochloride) in eighty parts of water. A fine dark red will be the result.

(d) Immerse the wood in a strong and hot decoction of Brazil wood and alum.

(e) Apply to the wood a hot mixture of dragon's blood and oil of turpentine.

(f) Treat the wood by immersion or application with a solution of annatto (eight to sixteen ounces) in 1 gallon of boiling water. This gives an orange red.

(g) Paint the wood with linseed oil reddened by being heated to 70 degrees C. or 80 degrees C. with alkanet.

(h) A simple solution of orchil gives a violet red and an acidified solution a bright red. It is preferable to mordant the wood first with a 5 per cent. solution of alum and a similar solution of potash or soda, and if the best possible result is aimed at, a little tin salt should be added to the solution of orchil.

(i) After mordanting with acetate of aluminum use a lukewarm solution of madder or alizarine.

(j) Decoctions of Brazil wood give various red shades to wood according as the decoction is mixed with alum, soda, lime, or acetic acid, and according to whether the preliminary mordanting was done with alum or with acetate of aluminum.

(k) Milk of lime reddens cherry wood, and if a subsequent treatment with a hot decoction of mahogany sawdust is employed, a very passable imitation of mahogany is obtained.

(l) Coralline reddens wood which has been soaped with a 3 per cent. solution of soap, but it is much better to mordant the wood with a solution of zinc chloride at 4 degrees B., and then to dye in a bath of coralline made soluble with caustic soda. 2½ pounds of coralline require 1 gallon of lye, and the shade is regulated by adding water. If alum is added to the dye bath, an orange shade is given to the red.

(m) With eosine colors, when only light shades are required, a cold bath of a solution of common salt of 5 degrees B. containing one-tenth per cent. of dye is sufficient, but for darker shades the wood should first be mordanted with a solution of acetate of aluminum of 4 degrees B., then treated with sulphoricinoleate of ammonia (soluble oil), and be then dyed in a bath containing five to ten parts of eosine (according to the shade wanted), thirty parts of acetate of aluminum, and 1,000 parts of water. Another way is to begin with a hot bath of 2 per cent. soap solution, then to mordant with a 2 degrees B. solution of lead acetate, and finally to dye in an eosine bath at 60 degrees C.

(n) Substantive colors can be used without mordants; e. g., Congo red, Congo G, Congo-corinth, benzopurpurine, and deltapurpurine. But they answer much better if they are fixed afterward with soluble oil or with acetate or nitrate of copper. Dye the wood at the boil with a solution containing 5 pounds of sodium carbonate, 5 pounds of dye, and 3 pounds of soap in 10 gallons of water, and fix afterward with a bath consisting of 25 pounds of soluble oil, 5 pounds of crystallized soda, and 10 gallons of water. In the dye bath borax or sodium sulphate may be substituted for the carbonate of soda, and the whole process may be worked with one single bath, composed as follows:

Congo red	2	lb.
Soluble oil	5	lb.
Potash soap	2	lb.
Aluminate of soda	1½	lb.
Water	10	gal.

(o) Aniline-ponceaux answers well on wood modanted with alumina. The wood is treated first with alum, then with silicate or carbonate of soda, and lastly with the dye.

Violet.—Dye the wood with aniline red and tin salt, after a previous treatment with one part of calcined soda, three parts of olive oil, and fifteen parts of hot water.

Yellow.—Mordant the wood with acetate of aluminum, and then dye it with decoction of quercitron or of turmeric.—Oils, Colors and Drysalteries.

IN GERMAN NEW GUINEA.

New Guinea, which is now being colonized by Englishmen, Germans, and Dutchmen, is inhabited by the Papuans, a primitive people of whose descent and ethnological position scientists are not yet fully decided, and of whose spiritual life but little is known. On that account we should not fall into the error of depreciating their civilization, or regarding it exclusively with the eyes of the European; for the Papuans in the arts which, by necessity, they are compelled to practice, have attained to a stage fairly advanced for the savage race. The potteries of Bili-Bili, for example, are well known and supply a large portion of the coast of Kaiser Wilhelm Land with their wares.

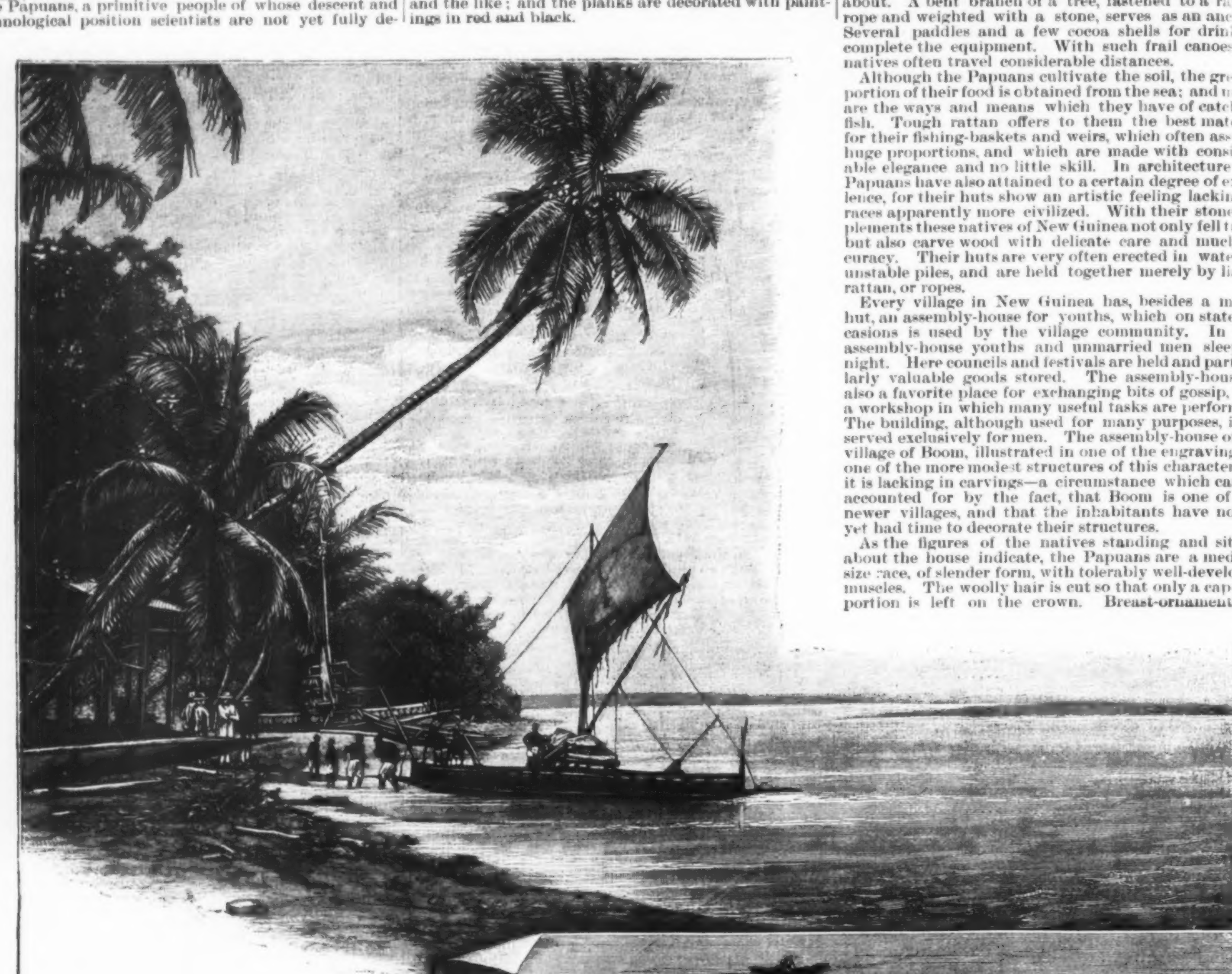
The first of our illustrations carries us to Astrolabe Bay, at present the economical center of Kaiser Wilhelm Land. Cocoa palms, with trunks partly inclined, indicate that a village must be near. In the foreground is a native canoe. The hulls of these canoes are formed of a single hollowed tree. Planks laboriously cut from a tree trunk are lashed together on the hull, the seams being calked by gum obtained from the bark of the wild bread-fruit tree. The bow and mast are ornamented by carvings, leaves, nautilus shells, and the like; and the planks are decorated with paintings in red and black.

The canoes have booms and one or two masts carrying mat-sails of pandanus leaves. In the canoe a deck or platform is built upon which a second covered story is erected, in which the natives sit when traveling about. A bent branch of a tree, fastened to a rattan rope and weighted with a stone, serves as an anchor. Several paddles and a few cocoa shells for drinking complete the equipment. With such frail canoes the natives often travel considerable distances.

Although the Papuans cultivate the soil, the greater portion of their food is obtained from the sea; and many are the ways and means which they have of catching fish. Tough rattan offers to them the best material for their fishing-baskets and weirs, which often assume huge proportions, and which are made with considerable elegance and no little skill. In architecture the Papuans have also attained to a certain degree of excellence, for their huts show an artistic feeling lacking in races apparently more civilized. With their stone implements these natives of New Guinea not only fell trees, but also carve wood with delicate care and much accuracy. Their huts are very often erected in water on unstable piles, and are held together merely by liana, rattan, or ropes.

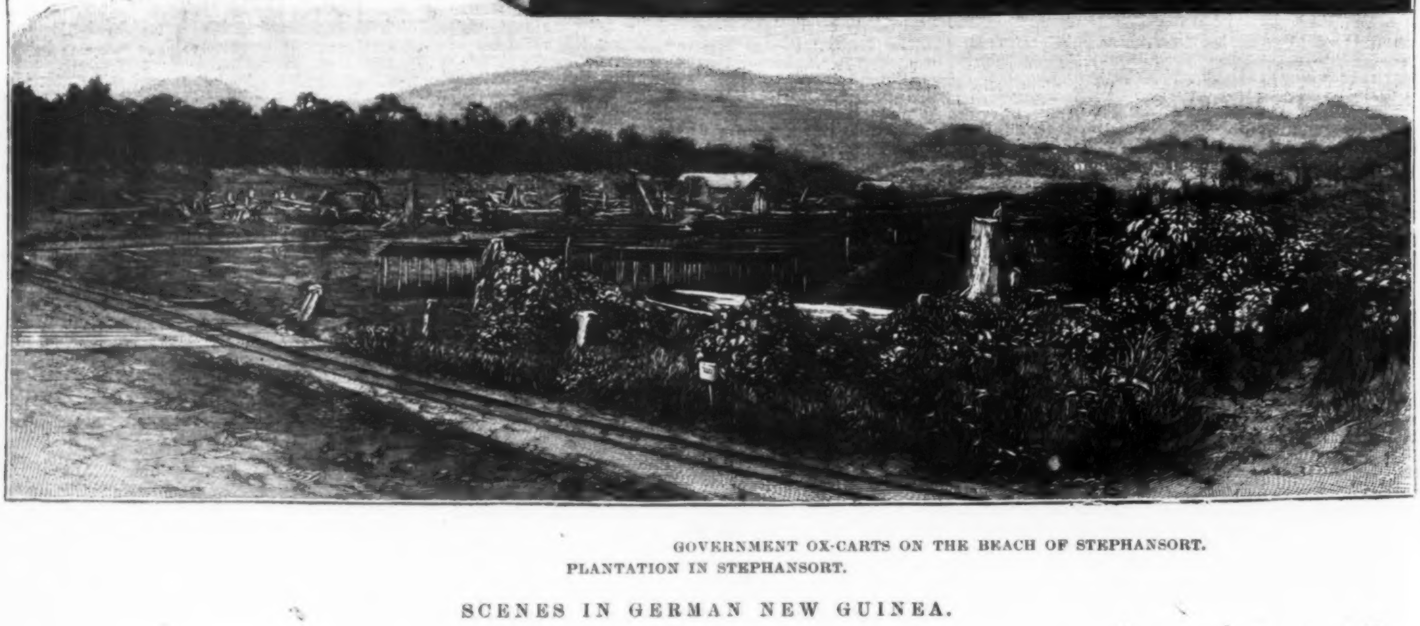
Every village in New Guinea has, besides a magic hut, an assembly-house for youths, which on state occasions is used by the village community. In this assembly-house youths and unmarried men sleep at night. Here councils and festivals are held and particularly valuable goods stored. The assembly-house is also a favorite place for exchanging bits of gossip, and a workshop in which many useful tasks are performed. The building, although used for many purposes, is reserved exclusively for men. The assembly-house of the village of Boom, illustrated in one of the engravings, is one of the more modest structures of this character, for it is lacking in carvings—a circumstance which can be accounted for by the fact, that Boom is one of the newer villages, and that the inhabitants have not as yet had time to decorate their structures.

As the figures of the natives standing and sitting about the house indicate, the Papuans are a medium size race, of slender form, with tolerably well-developed muscles. The woolly hair is cut so that only a cap-like portion is left on the crown. Breast-ornaments of



LANDING OF TRADERS FROM THE ISLAND OF BILI-BILI, UPON THE BEACH OF BOGADJIM.

GOVERNMENT OX-CARTS ON THE BEACH OF STEPHANSORT.



PLANTATION IN STEPHANSORT.

SCENES IN GERMAN NEW GUINEA.

boar tusks, ear-rings of tortoise shell, are worn by many natives.

Most savages are decidedly averse to being photographed. In the present case this antipathy was overcome by persuading the natives that only the plate held in the hand of one of their companions would be photographed. That the entire band would be upon the picture they, of course, did not suspect.

Plantations are being cultivated between the mountain chains of the interior and the coast. Of these the tobacco-plantations are of no little importance.—Ueber Land und Meer.

GEOGRAPHICAL DISCOVERY.

"A NEW era is approaching in the historical development of geographical discovery. The pioneers will soon have played their part; the white patches on the maps of the continents are gradually growing smaller; our knowledge of the physical conditions of the ocean is every year becoming more complete." The pioneer is giving way to the explorer, who searches with intelligent and persistent scrutiny the surface of the earth and all its restless life, forever finding new gaps to fill, new problems to solve, says The Literary Digest. In the interior of Asia vast regions still invite the investigations of the well equipped and intrepid explorer; such as the appalling expanse of the almost inaccessible desert of Gobi, the endless wastes in the highlands of Tibet, to this day as mysterious as the Polar regions. Even the charts of Africa cannot now show a "white patch" of such extent as appears under the name of Tibet on our maps of Central Asia. In this respect the Polar regions alone are comparable with Tibet—that land whence the light of revelation streams out upon the world of Lamaism, even as its waters roll down to give life and nourishment to the regions round about. "I thought it better," says Sven Hedin, in his new book, "Through Asia," "to work those parts of Northern Tibet which were still terra incognita. Everywhere there, with the exception of the point where I should intersect the route of Bonvalot and Prince Henri of Orleans, I should be the first European pioneer, and every step would be an accession of geographical territory, every mountain, lake, and river a discovery."

And so this undaunted young Swede mapped his way "through Asia" 6,520 English miles—that is to say, nearly four and a half times the distance from London to Constantinople, two and a half times the distance from New York to San Francisco. "If to this be added more than 8,000 miles that I traveled by carriage or rail in parts of the continent, we get for the entire extent of my travels a grand total of 14,600 miles, or more than the distance from Pole to Pole."

Across the steppes, with the half-savage but good-humored Kirghiz, the steppes so grand and impressive, though utterly monotonous and melancholy, his rude tarantass was always the center of a vast expanse, without boundary or horizon, so vast indeed that it seemed almost possible to discern the globular shape of the earth:

"In a country across which the stranger may travel for days and days without, so far as he can perceive, anything to vary its uniform flatness, and across which there is not the slightest indication of a road, the Kirghiz finds his way, even at night, with unerring certainty; he notices the places where the tufts of grass grow more thinly or more closely together than usual. He can discriminate the color of a horse on the horizon

WEAVING FISHING-TRAPS IN THE VILLAGE OF GARIMEH.

IN THE VILLAGE OF BOOM, NEAR STEPHANSORT.

SCENES IN GERMAN NEW GUINEA.

long before the stranger is even able to discover its presence; and he can tell whether a cart which, seen through a field-glass, appears a mere dot in the distance, is advancing or receding."

On the borderlands between East and West Turkestan the earth's crust is thrust upward into a lofty mountain-knot of gigantic dimensions, from which radiate some of the most stupendous ranges: eastward the Kwen-lun, southeastward the Himalayas, and between these the Kara-Korum range, stretching into Tibet. Toward the southwest are the Hindu-Kush Mountains, according to several authorities the home of the first parents of the human race. The traditions of a dim antiquity declare that the four sacred rivers of Paradise had their springs in these sublime altitudes. The people of High Asia still revere the Pamirs, styling them the "Roof of the World," and regarding them as the coign of vantage from which the towering mountain-giants look abroad over the whole creation.

Shut in by mountain chains is the saline lake of Kara-Kul, a Kirghiz name meaning the Black Lake, with an area of about 140 square miles. Here the adventurous party were confronted by the mystery of the ice, and Sven Hedin's story of it is told in the spirit of Marco Polo:

"As we moved along, every step the horses took was accompanied by peculiar sounds. One moment there was a growling, like the bass notes of an organ; the next, it was as though some one were thumping at a big drum in the flat below; then came a crash, and then a splash as though a big round stone had been flung into the lake. These sounds were accompanied by alternate whistlings and whinings, while now and again we seemed to hear submarine explosions afar off. At every loud report the horses twitched their ears and started, while the men glanced at one another with superstitious terror. The 'Sarts' believed that the sounds were made by big fishes knocking their heads against the ice. But the more intelligent Kirghiz instructed them that there were no fish in Kara-Kul. Then, when I asked them what was going on there, they answered with true Oriental phlegm, "Khoda billadi!" (God only knows.) Anyway, if the faithless Lady Ran (the goddess of lakes in the old Scandinavian mythology) were hatching mischief against us, she strangely miscalculated her powers. The ice did not break; it would have borne the whole city of Stockholm."

And the great mountain of Mus-tagh-ata! Whenever the Kirghiz pass it, or when they first get sight of it in the course of a journey, they fall upon their knees and pray. It is the abode, they say, of threescore and ten holy ones, and the gigantic burial ground of saints. There dwell the souls of Moses and Ali, the son-in-law and nephew of Mohammed. The Kirghiz sometimes call the mountain "Hazrett-i-Musa" (Holy Moses).

They tell of the ancient city of Janaidar, on the summit of Mus-tagh-ata—built in the days when peace and happiness reigned over all the world. In Janaidar the fruit trees still bear their luscious burden the whole year round; in Janaidar the flowers never wither, and woman is ever young and beautiful.

Mus-tagh-ata towers to the height of 25,600 feet, and like a mighty bastion overlooks the wastes of Central Asia. It is the culminating point of a meridional chain that is worthy to rank with the stupendous ranges that converge upon the Roof of the World—the Himalayas, Kwen-lun, Kara-Korum, Hindu-Kush. "Many a time," says Sven Hedin, "have I gazed with wonder upon Mus-tagh-ata from afar off; many a month have I wandered on its ragged flanks."

Most impressive by moonlight was the "Father of the Ice," when it shone upon the great glacier defiles and the grandeur of its black perpendicular rocks, amid the dull cracking of new crevasses forming, or the crash of an avalanche. Then the forms of the yaks were thrown up in sharp relief against the white snow, their heads drooping low, silent as the stones they were bound to:

"Every now and then they ground their teeth against the fibrous pad of the upper jaw, or crunched the snow under their feet as they changed position. The three Kirghiz who could not be accommodated inside the yurt made a fire between the rocks; and when it died out, they crouched in a kneeling posture with their heads on the ground, wrapped in their fur coats and huddled together like bats in winter. . . . The architecture of nature was conceived here on a bold and masterful plan—the blue glacier, sunk between its black walls of rock, sheathed in mail of ice and snow. The dark crest in the southeast was alive with white-veiled figures gliding in a strange elf-dance across the surface of the glacier, away over the northern summit of the 'Father of the Ice Mountains.' . . . I seemed to see the white camel that brought the dervish down from Mus-tagh-ata; the forty horsemen who supported Khan Khoja against the Chinese host; the Blessed Ones of Janaidar, the city of bliss."

Four times, and still in vain, did Sven Hedin essay the ascent of Mus-tagh-ata before he bade farewell to that sovereign of the giants of the Pamirs—at once a corner-stone of the earth's loftiest mountain range and the topmost pinnacle of the Roof of the World; among the lights of Asia one of the brightest among the towering eminences of earth, one of the most sublime.

Sven Hedin traversed the desert of Tak-a-Makau, and his story of that awful crawling tragedy of thirst and famine and despair and death is enough to make the bones of the reader rattle and his tongue cleave to the roof of his mouth. Some of them called the desert Dekken-dekka, because a thousand and one towns are said to be buried under its wastes of sand:

"Whence come these legends? Is it merely by accident that they fly from mouth to mouth in Khotan and Yarkand, Maralbashi and Ak-su? Is it merely for the sake of making themselves interesting that the natives describe in detail the deserted houses, which they say they have seen, and where once there were great forests, the home of big game? These legends must have a foundation in facts."

The intrepid and romantic explorer was fascinated. He became blind to danger; he had fallen under the weird spell of the desert. Over there, on the verge of the horizon, were the rounded forms of the sand-dunes, and beyond them, in the sepulchral silence, stretched the unknown, the enchanted land, of whose existence not even the oldest records tell, the land he was going to be the first to tread.

At Yarkand the people believe that the traveler through the desert often hears voices calling him by name; he follows them, and he dies of thirst. So Marco Polo wrote of the Great Desert of Lop, "sometimes the spirits will call him by name, and thus shall a traveler oftentimes be led astray, so that he never finds his party."

Very soon the adventurous caravan passed from the last patch of hard clay soil into the sand; the last of the tamarisks, which still defied the visitation of death, was left behind. Not a blade, not a leaf, was to be seen—nothing but sand, sand, sand, fine yellow sand, seas of sand, mountains of sand. No bird flitted across the gray sky; no track of deer or gazelle wrote of life in the dust; even the last promontory of Masar-tagh had vanished.

When Islam Bai, the brave, the patient, the faithful Islam, cried "Karga! karga!" and pointed to a raven circling round the caravan, there was joy in the hearts of all; that raven had not sought the depths of the desert for the pleasure of the thing. Khotan-daria must be close at hand. With compass in one hand and field-glass in the other, Sven Hedin plodded eastward, for there ran the river of safety. The camp, the camels, were lost to sight behind the summits of the sand hills. His only companion was a solitary fly:

"Noon came, and I was near fainting with fatigue and thirst. I was dead beat. Then my friend, the fly, swung round to the other side of me, and buzzed a lively tune: 'Just a little farther. Drag yourself to the top of the next dune. Tramp off another thousand paces, before you give in. All the nearer to Khotan-daria; all the nearer to the flood of fresh water that rolls down to Lopnor, the dancing waves that sing the song of life and spring.' Then I dropped on the top of a dune, rolled over on my back, and pulled my white cap over my face."

Between two sand dunes lay a portion of the skeleton of a donkey, or, as the men insisted, a wild horse; only the leg bones, white as chalk, and so brittle that they crumbled to the touch. What was the creature doing in the desert? How long had its bones lain here? For thousands of years, perhaps.

They found clay mixed with sand, and it was moist. By the light of a couple of candle ends stuck in the sandy sides, they dug for a well. The camels, impatient, stretched their long necks, and sniffed at the cool wet sand. Yolldash, the dog, squatted in it, with his legs outstretched. Inch by inch the diggers burrowed; they would find water. Kasim, half-naked, looked wild and eerie. All at once he stopped digging, letting the spade drop from his hands. Then, with a groan, he fell to the ground. "Kurruk-kum!" the sand was dry, dry as tinder. And the last of the tanks contained only water enough for one day. For three days the camels had not tasted a drop, nor did they get a drop more. Hedin writes:

"Going down the side of one of the dunes, my eye fell upon a small object resembling a root. I stooped to pick it up, when suddenly it darted away, and disappeared in a hole on the edge of the dune. It was a lizard, yellow, like the sand. How did the creature live? Did it eat nothing? Did it never want a drop of water to drink? . . . Yolldash (the dog) kept close to the tanks, in which he could hear the last few precious drops splashing against the sides, and whined and howled. Whenever we stopped, uncertain which way to turn, he yelped and sniffed at the tanks, and scratched in the sand, as if to remind us that we must dig a well."

Mohammed Shah reported that even at the beginning of the day's march the camels refused to move, and he had abandoned them to their fate. "I was to blame for the loss of the innocent lives. It was I who was answerable for every pang of pain, every moment of agony, which the men and the animals of my caravan suffered. It weighed upon my conscience like a nightmare."

Then came the hurricane and the sand-storm—kara, buren, the black storm. The going that day was fearful; they knew not which way to take. They must stick together, close, men and animals in a bunch. Nothing was to be heard but the strange whining and moaning of the sand. Perhaps it was this eerie sound that worked upon the imagination of Marco Polo, when he wrote, "Even in the daytime one hears these spirits talk. And sometimes you shall hear the sound of a variety of musical instruments, and still more commonly the sound of drums."

There were two tumblerfuls of water left in one of the pitchers. They had given to the camels all the bread they had. Islam Bai caught Yollchi, the guide, with his back to his comrades and the pitcher at his mouth. He had drunk half of what there was, leaving about one-third of a pint for all the others:

"I dragged myself on, a few steps farther; then I fell again. I scrambled up, reeled on, and once more fell. I could no longer hear the bells of the camels. . . . . With great difficulty, Islam helping me, I scrambled to the white camel's back, but he refused to rise. Mohammed Shah was delirious, laughing to himself, weeping, babbling, playing with the sand, letting it run between his fingers."

At last the horizon showed a black border. What joy! what joy! It was the forest that bordered the bank of Khotan-daria! Then they entered the thick, continuous woods:

"For weeks we had been dragging ourselves, dying by inches, through the valley of the shadows of death—and now! All around us, life and spring time, the singing of birds, the scent of the woods, green leaves of every tint, refreshing shade; and over there, among the hoary patriarchs of the forest, innumerable spoor of wild animals—tigers, wolves, deer, foxes, antelopes, gazelles, hares. The air was alive with flies and midges; beetles went whizzing past us, swift as arrows, their wings humming like the notes of an organ; and the morning songs of birds from every branch."

But the river—where was that? There was a thicket of bushes and reeds; a poplar, blown down by the wind, lay across a deep hole in the dry river-bed. A wild duck, startled by the approach of men, flew up and away. Sven Hedin heard a splash, and then—he stood on the brink of a little pool of fresh cool water!

According to the French garden magazine La Jardin, the Hortensia can be made to have blue flowers by using fertilizers composed of equal parts of heath mould, coal cinders, and vegetable mould.

LOW TEMPERATURES.*

By Prof. P. CARMODY, F.I.C., F.C.S.

LESS than two hundred years ago (1724), when Fahrenheit tried to produce low temperatures by artificial means for the purpose of placing the zero mark on his thermometer as low down as possible, it is said that he fell into the not uncommon error of boasting that no one could produce a lower temperature than he had obtained by mixing snow and salt together. In every age there are limits of knowledge, and especially in scientific subjects. The "great beyond" is ignored by some and unexplored by any belonging to that age; but in subsequent ages these limits are so considerably extended that their existence is apt to be forgotten and their past impenetrability very difficult to realize. Succeeding generations will smile at our failures to extend the present limits in the same way as we do at those of our predecessors. In his wildest dreams Fahrenheit could hardly have imagined that before the year 1900 scientists would have probed the depths of temperature 400° below the point he evidently regarded as a very creditable achievement.

The public have recently heard so much of low temperatures in connection with the liquefaction of air that a brief survey of past work in this direction cannot fail to be of interest. It is a record of persistent effort discouraged by failures, but eventually rewarded by success. The work is not by any means at an end, and the practical advantages to be derived from it are but in their infancy.

PRODUCTION OF LOW TEMPERATURES.

For convenience we may divide the methods for producing cold artificially into three classes:

1. The rapid solution of a solid.
2. The rapid evaporation of a volatile liquid.
3. The rapid expansion of a cooled compressed gas.

Each method has advantages peculiar to itself. The first requires no elaborate machinery, but is useful only for moderately low temperatures for a short period of time. The second, by the aid of apparatus, more or less expensive, can produce moderate or very low temperatures. The third can only be utilized with complicated machinery, and is most economic for moderately low temperatures for long periods of time.

The first is commonly known as the method of "freezing mixtures," and the third is associated in the popular mind with refrigerating or cold storage rooms. The second has received no popular name. Indeed, it is less generally known, although to it we are indebted mainly for the brilliant achievements which, in 1845, and again in 1877 and 1884, crowned the persistent efforts of scientific workers, and culminated in the production of cupfuls of liquid air to the astonishment of the general public.

The first method was used by Fahrenheit and other experimenters previous to 1820. The best results obtained never exceeded —50° C. (—58° F.)†; but this temperature was sufficient to convert a great many liquids into solids and a few gases, viz., sulphur dioxide, chlorine, and ammonia, into liquids. These results led to the inevitable conclusion that solids, liquids, and gases were but different forms of matter through which each kind of substance could be made to pass by the addition or withdrawal of heat. Water, for instance, could be converted into solid ice by the withdrawal of heat or into the gas called steam by the addition of heat; and it was held that every known substance would behave similarly, if heated or cooled sufficiently. Accordingly, efforts were made to reduce gases to liquids and then to solids by cooling them; and this was the main object in view in all the experiments in connection with low temperatures. As long as only the first method was employed, the liquefaction of gases was limited to the three above named.

FARADAY'S WORK WITH PRESSURE.

In 1823 Faraday succeeded, by means of pressure alone, in liquefying a large number of gases; and in 1845, by combining pressure and cold, he succeeded in liquefying all except six, viz., oxygen, hydrogen, nitrogen, nitric oxide, carbon monoxide, and marsh gas. In his experiments he first made use of freezing mixtures, but subsequently he utilized the discovery made by Thirlorier in 1835, who liquefied carbonic acid under great pressure in an apparatus constructed of iron on the same principle as the glass apparatus used by Faraday in 1823. Thirlorier showed that liquid carbonic acid, or the solid carbonic acid (which he also obtained), mixed with ether, gave on rapid evaporation a temperature of —100° C. (—148° F.); and by this means Faraday produced a temperature of —110° C. (—168° F.) This was 60° C. below the best results obtained with freezing mixtures. Faraday's magnificent researches proved beyond doubt that all gases could be liquefied by cold.

Beyond the narrow limits of scientific circles, very little was known of these results. But in 1862, at the International Exhibition, Carré exhibited a machine for the manufacture of ice, and public attention was drawn to the practical utility of these researches after low temperatures. The cold in Carré's machine was produced by the rapid evaporation of liquefied ammonia; and to this day ice is made by this means.

Faraday's record of 1845 was not surpassed until 1873, when Natterer, by the evaporation of a mixture of liquid carbon disulphide and liquefied nitrous oxide, reached a temperature of —140° C. (—220° F.)

PICTET LIQUEFIES AIR, OXYGEN, AND HYDROGEN.

Up to this time the machinery used was not of a very complicated or expensive description; and it was foreseen that future success depended on improved apparatus. Working on these lines, Pictet and Cailletet independently devised new machinery, and almost simultaneously succeeded in 1877 in liquefying oxygen, air, and hydrogen, and in showing how the remaining gases could be liquefied.

But they did not succeed in collecting any considerable quantity of these gases. By further improvements in machinery, Olszewski in 1885 collected liquid air and oxygen in any desired quantity, and not only liquefied but solidified nitrogen, carbon monoxide, marsh gas, and nitric oxide. To him belongs the further credit of having lowered the record to —225° C. (—373° F.), the

* The British and Colonial Druggist.

† The greatest natural cold on the earth's surface is —89° F.

lowest known up to that time. Since then he has further lowered it certainly to —240° C. (—400° F.), and almost certainly to —264° C. (—444° F.), which is but a few degrees from —273° C., the absolute zero of temperature. Up to the present (1898) this is the lowest temperature recorded.

Dewar, Wroblewski, and others have done excellent work in devising new apparatus; but for the application of new principles, credit must solely be given to Faraday in 1845 and Pictet and Cailletet in 1877.

It will be necessary to add a few words about the absolute zero of temperature, which possesses as mystic an attraction for cold producers as the North Pole does for explorers. It has been already stated that the principle and immediate object in obtaining low temperatures was the conversion of gases into liquids. It had long been observed that heat expands and cold contracts all substances, whether solids, liquids, or gases; but with the latter the rate of expansion and contraction was much larger, and so uniform that the well known law: Gases expand or contract $\frac{1}{273}$ of their volume at 0° C. for each "rise or fall of 1° C." was promulgated and used in all calculations connected with weights and volumes of gases.

As observation had shown that gases on cooling exhibited a tendency to become liquids, it was assumed that all gases must liquefy if sufficiently cooled, and that, if the above law were correct, no gas could exist as a gas* at a temperature of —273° C. Although other researches have shown that gases do not obey this law at temperatures approaching that at which they become liquids, experimenters have never ceased in their endeavors to approach nearer and nearer to this absolute zero of temperature. With the exception of the newly discovered gas helium, all known gases have been liquefied. Air, being mainly a mixture of two gases—nitrogen and oxygen—could easily be liquefied, as soon as the method for liquefying its separate constituents was discovered.

The details of the methods employed in producing the foregoing astonishing results are marvels of patient plodding and inventive restlessness. At the time when freezing mixtures were the only known means of producing cold, the following may be taken as typical examples of the best results obtained:

—22° C. by dissolving common salt in snow.

—46° C. by dissolving caustic potash in snow.

—50° C. by adding cooled dilute sulphuric acid to snow or by dissolving calcic chloride in ice.

In all the above cases the chemicals employed absorb water rapidly from the snow or ice, causing them to liquefy in a shorter time than they would ordinarily require.

Experiment had repeatedly shown that rapid liquefaction of a solid was always accompanied by the production of cold; and a long list of freezing mixtures may be found in any text book of chemical physics or in any encyclopedia. A familiar example of their utility is seen in the household ice cream making machines, which are all worked on this principle.

A familiar instance of the second principle is the cooling of water by its own evaporation through porous jars or ordinary bottles surrounded with a damp cloth. On hot days the evaporation of the water on the outside of the jar is so rapid that the contents are cooled several degrees below the atmospheric temperature.† But ordinary water evaporates too slowly, and more volatile liquids are chosen instead. Since Faraday's time we owe all our successes to various applications of this principle. The great advantage possessed by this principle, and in which it chiefly differs from the others, is that it admits of being applied in successive stages. We begin with an easily liquefiable gas, and utilize the liquid produced from the liquefaction of a gas liquefying at a lower temperature. This in turn liquefies another, and our cold production is only limited by the number of gases and the difficulty of maintaining them at the low temperatures at which they liquefy. The temperature at which a liquefied gas becomes reconverted into vapor, or, in other words, its boiling point, is an index of the degree of cold it is capable of producing; for, as long as any liquid remains while being converted into a gas, the temperature of that liquid never rises above its boiling point. A glance at the following table of boiling points will show what temperature each liquid will produce when evaporating under ordinary atmospheric conditions.

TABLE OF BOILING POINTS OF LIQUEFIED GASES.

(At ordinary atmospheric pressure.)

	Deg. C.
Sulphur dioxide	— 10
Chlorine	— 33
Ammonia	— 38
Sulphureted hydrogen	— 62
Carbon dioxide	— 78
Nitrous oxide	— 88
Ethylene	—102
Nitric oxide	—153
Marsh gas	—164
Oxygen	—183
Argon	—187
Carbon monoxide	—190
Air	—192
Nitrogen	—195
Hydrogen	—238

These boiling points are the liquid temperatures during spontaneous evaporation; but if the rate of evaporation be increased artificially by removing the atmospheric pressure, a much lower temperature is registered. Hastening the evaporation of a liquid in this method produces the same effect as hastening the solution of a solid in the method of freezing mixtures.

It can now be easily understood how to make use of this method in successive stages. We begin, say, with a freezing mixture capable of reaching —50° C. This liquefies the three gases at the head of the list. We preferably omit chlorine from further experiment on account of its action on the metal and washers of machinery, and, by choosing sulphur dioxide and causing it to evaporate rapidly in an exhausted vessel, can produce a temperature of —65° C., which is sufficiently cold to liquefy carbon dioxide when that gas has been slightly compressed. With liquid carbon dioxide a temperature of —78° C. is shown on spontaneous evaporation, but in an exhausted vessel the temperature falls to —110° C. This temperature liquefies nitrous oxide and ethylene, pressure being in all cases added when necessary. Liquid nitrous oxide mixed with carbon disulphide gives, on similar evaporation, a temperature of —140°; and liquid ethylene evaporating in vacuo produces a temperature of —160° C. to —170° C. With this and pressure, air, oxygen, and nitrogen can be liquefied; and, finally, by means of liquid oxygen or air, we can liquefy hydrogen.

CONTRASTS OF PICTET'S AND FARADAY'S WORK.

Faraday was the first to make use of the great cold produced by the evaporation of a liquefied gas, Pictet the first to use such gases in succession. Faraday's pressures did not exceed 60 atmospheres, Pictet's exceeded 650, Cailletet's were about 300. The latter cooled his compressed gas principally by its own sudden expansion (third method). Such enormous pressures as those employed by Pictet and Cailletet required the use of specially strong apparatus, and all subsequent experimenters have endeavored to work with greater cold and less pressure. To experimenters subsequent to Pictet and Cailletet belongs the credit of devising apparatus suitable for storing the liquefied gases. The surrounding air is a fiery furnace to some of these liquefied gases—its temperature being 150° to 200° C. above that at which they boil. From this atmosphere, if it is intended to preserve them as liquids, they must be protected by interposing layers of non-conducting substances, and the best non-conductors are the liquids themselves. The inner receptacle must be surrounded by three or four others, and the following arrangement shows how the inner vessel is kept sufficiently cold:

Air surrounding outer receptacle, about 15° C.

	Deg. C.
First (outer) liquid carbon dioxide and ether	—110
Second liquid ethylene	—160
Third liquid oxygen or air	—180 to —190
Fourth (inner) liquid oxygen or air	—180 to —190

Even with this protection there is a good deal of loss by evaporation, but it is possible to store them in this way for a considerable time.

Although the results so far obtained are only of scientific interest, they possess enormous potential values, and commercial applications of them will certainly follow. Liquid air especially would find thousands of practical uses.

The third method will only be referred to for the purpose of including it with the others. It is not intended here to deal with the subject of cold storage chambers for the conveyance of meat, fruit, etc., with which this method is principally connected. Reference has necessarily been made to it under Cailletet's process for liquefying gases, and in his hands it has contributed to some of those astonishing results described chiefly under the second method. It is very probable that it will be the means by which helium shall follow the fate of all other gases.

We can readily conceive that this brief record of successes gives but an inadequate idea of the actual amount of work that has been done in connection with this subject during the past 170 years. A record of the failures would certainly occupy a much larger space, and might prove no less instructive. But of the failures we hear not. We only know that to produce these results science must be ever restlessly probing in this direction and in that, and constantly utilizing past successes as stepping stones to future triumphs. Faraday's bent glass tubes suggested a stronger apparatus to Thirlorier, and Thirlorier's liquefied carbonic gas proved a useful tool in Faraday's hands. Pictet and Cailletet in their turn owe much to Andrews for his discoveries in critical temperatures, the knowledge of which enabled them to avoid the causes which prevented Faraday's complete success.

* It is often erroneously stated that scientists expect that matter will cease to exist at —273° C.

† In 1755 Dr. Cullen succeeded in freezing water by its own evaporation.

IS THE WORLD NEARING STARVATION?

DIVERS statisticians are telling us that the world's population is growing so fast that in a few centuries there will not be food enough to support it. A Belgian statistician, Gen. Brialmont, thinks this time will come in less than four hundred years. In Cosmos (translation of the Literary Digest), Dr. Albert Battandier reviews the Belgian general's arguments and concludes that there is not so much to fear, after all; but it cannot be said that he is very reassuring, for he merely puts off the evil day, and then tells us to trust in Providence. Says Dr. Battandier:

"The economists and the statisticians are beginning to cry out in alarm. They calculate the population of the earth at different epochs, deduce the annual increase, and, going on from this, find by a simple example in proportion the number of persons that the world should contain at a given future date. This done, they estimate the area of ground necessary to support one man, and soon are able to assure us that in four hundred years the population of the globe will be so dense that the earth can no longer nourish its inhabitants and that hundreds of millions of human beings must die yearly of hunger. They nevertheless find a correction to this sad prophecy in the thought that the successors of M. Berthelot may have discovered by that time a means of manufacturing nutriment chemically. Bread, meat, vegetables, will then be only a distant memory, and a dinner menu will be made up somewhat as follows: A small tablet of nitrogenous matter, pastilles of fatty material, a little sugar, and a bottle of seasoning—all pure and free from microbes. And then, when the nourishment of man is no longer a daily problem, when we are no longer forced to ask humbly of God our daily bread, the earth will become a vast garden watered by subterranean streams raised to the surface, and the human race will live in the legendary abundance of the Golden Age.

"Let us rapidly examine the divers elements of this complex problem and see whether some of them are not contrary either to logic or to fact.

"The first question to be put is that of the present figure for the population of the globe and its annual increase during the last twenty-five years. These statistics, we should say, are far from being official. Although scientists of great authority have compiled them, these have had at their disposal only approximate figures. Who has told them the number of inhabitants of Australia and of Central Africa? How have they counted the 200,000,000 of men that they set down to this country? It may be easy to find out, at least within several millions, the population of British India, but to do the same for Central Asia is quite a different matter. Siberia is almost in the same category, and as for China, it suffices to glance at the different estimates of her population to find variations of nearly 100,000,000. North America has regular statistics, but it is not the same in South America, where perpetual revolutions, which interfere with the economic development of the continent, have the same effect on the statistics of population.

"This being established as a necessary preamble, let us examine some of the statistics given by different authors:

Malte Brun—1810	653,000,000
Hassel—1817	967,000,000
Sociétés Bibléques—1824	1,000,000,000
Balbi—1826	828,000,000
Ausland—1830	872,000,000
Dieterici—1866	1,283,000,000
Behm and Wagner—1871	1,391,000,000
Levasseur—1878	1,439,000,000
Behm and Wagner—1883	1,434,000,000
Levasseur—1886	1,483,000,000
Wagner and Supan—1891	1,480,000,000
Estimate for 1895	1,540,000,000

"The meaning of these figures is that it is at present impossible to get an idea of the population of the globe, even within 100,000,000, and the different estimates that have been given show how fragile is the base on which must be built any inductions drawn from these estimates. Nevertheless, Gen. Brialmont has made the attempt.

"Starting from the fact that in 1882 the population of the globe was 1,392,000,000, and that in 1890 it had risen to 1,480,000,000, he figures out, to begin with, an annual increase of 6·3 per cent. In the same way he concludes that in 1978 the population of the globe will be 2,890,000,000; 6,000,000,000 in the year 2074; 12,000,000,000 in 2166; nearly 23,000,000,000 in 2258; and 27,500,000,000 in 2282, or in 400 years.

"It is easy to see that this reasoning is based wholly on the two estimates of 1882 and 1890. Now we have seen how statistics differ, and consequently how trivial are the inferences made from them. Let us make the calculation for ourselves, saying that in 1824 the population was 1,000,000,000, and in 1894, seventy years later, 1,500,000,000. It follows that the annual increase is only 7,000,000, or seven-tenths of one per cent. yearly. We see how far we are from Gen. Brialmont's figures, and I believe that he will find it as hard to contest this estimate as to prove the exactness of his own. Besides, ours, having a wider base, should have the preference.

"According to the law of Malthus, 'when the population is not arrested by any obstacle, it doubles every twenty-five years, in geometrical proportion.' This gives an annual increase of 4 per cent., and the Belgian general finds 6·3 per cent., going, therefore, ahead of the too-celebrated English economist. Let us turn the process the other way about, and try to find out, by the aid of this progression, in inverted order, when the population of the globe should have started to have become a thousand millions in 1825. The calculation is very simple, since we have to do with twenty-five year periods. At the beginning of the century there should have been only 500,000,000, 250,000,000 at the beginning of Louis XVI.'s reign, and finally, keeping on in the same way, we shall find that in 1575 the population of the globe should have been only 1,000,000.

"But, it will be said, you forget that the law of Malthus has to do with an unarrested progress of population, while wars, famines, and plagues must be taken into account. Agreed; but then, since the world has not changed in the nineteenth century, it must be admitted that the same causes that have retarded the normal increase of population will continue to act, and to neglect their effects in our estimates is to commit an error. We should always take account of observed facts; we should admit that these diverse causes have exerted their retarding force in such wise that the period in which the population doubles, instead of being twenty-five years, is at least eight times as great, or two hundred years. By the same series of calculations, we shall find that at the beginning of the Christian era the population of the globe should have been only 2,000,000, when according to the official statistics of the Roman consuls, their city had at this time 1,336,000 inhabitants.

"Questions of population are not solely questions of arithmetic, and to consider them sanely we must introduce another factor whose existence does not seem to have been suspected by the Belgian statistician.

"This factor is divine Providence; and to be afraid of over-population is to show distrust of Providence.

"After having shown by his calculations that the population of the globe will be 30,000,000,000 in four hundred years, Gen. Brialmont asks with anxiety how such a crowd can be fed.

"The area of the earth is 510,000,000 square kilometers [197,000,000 square miles] from which we must subtract 379,000,000 [144,000,000 square miles] for the area of the ocean. It would not be exact to say, however, that this immense quantity of water is useless to the human race, and it seems, in fact, as if God had placed on the earth this inexhaustible mine of nutritive material to supply what the soil cannot furnish. The sea is an immense purveyor, whence our fishermen can draw largely without exhausting it; we cannot exclude it, therefore, in evaluating man's food supply.

"There remains 13,500,000,000 hectares [33,300,000,000 acres] of continents, from which we must take parts necessarily uncultivated, such as the polar regions, high mountain chains, space occupied by dwellings, etc. We shall thus have at our disposal not more than 2,000,000,000 hectares [4,900,000,000 acres] of land on which food may be grown. This being premised, we may count a hectare of land [2·47 acres] as able to nourish three persons at most, as in Belgium. The 2,000,000,000 hectares will then feed only 6,000,000,000 inhabitants—a figure which, according to the general's statistics, will be reached in 176 years.

"An old French proverb, rendering in rustic fashion a beautiful passage of Scripture, runs thus: 'When

God causes an ass to be born, he makes a thistle grow for it.' If God, who takes care of the tiniest bird, does not allow a hair of our heads to fall without His consent, why should He abandon us to the terrible fate predicted by statisticians who do not take Him into their calculations?

"But we may attack these statistical terrors more directly. First, the statisticians take no account of the immense surface of the sea and its products—the first important omission. How many people live wholly upon the fisheries, and what shall prevent man from doing with the ocean what he has already done with the rivers, and cultivate the immense extents where humanity will always find wherewith to satisfy hunger? Then, too, calculations based on ordinary agriculture are in error, for intensive culture has scarcely begun to be practiced, and we have great progress to make in the way of causing the earth to yield us more than she now does. . . .

"Finally, and this last reflection is all-sufficient—God is master of life and death. . . . Let not statistics appal us. In the early days of the world God said, 'Increase and multiply,' . . . and He has in His power the means needful for giving to all His children their daily bread."

THE HONEY BEE.

THE United States Department of Agriculture publishes an interesting pamphlet entitled "The Honey Bee, a Manual of Instruction in Apiculture," by Frank Benton, M.S. It is published as Bulletin No. 1 in the series of the Division of Entomology, and through the courtesy of the department we are enabled to present the following facts and illustrations.

The object of the pamphlet is to give in plain language the information needed by one who engages in bee keeping primarily for profit, but it is of great scientific interest as well, and it is more particularly this section of the subject with which we will deal. There are several varieties of the honey bee and the commonest of all is the common hive or honey bee (Apis mellifica), which was imported to this country some time in the seventeenth century, and is now widely spread from the Atlantic to the Pacific. Several other races have been brought here, including the Italian, Egyptian, Cyprian, Syrian, Palestine, Carniolan, and the Tunisian. Of these the brown or German, the Italian, and, in a few cases, the Carniolan bees, are probably the only races existing pure in the United States, the others having been more or less hybridized with the brown race or among themselves, or their cultivation has been discontinued. The first five engravings show the several varieties of the honey bee. Our sixth engraving shows the worker cells of the common honey bee.

Each colony of bees in good condition at the opening of the season contains a laying queen and some thirty to forty thousand worker bees, or six to eight quarts by measurement, besides there should be four, five, or six combs fairly stocked with a developing brood, with a good supply of honey about them. Drones may also be present, even several hundred in number, although it is better to limit their production to selected hives.

Under normal conditions the queen lays all of the eggs which are deposited in the hive, being capable of depositing, under favorable conditions, as many as four thousand eggs in twenty-four hours. Ordinarily she mates but once, flying from the hive to meet the drone—the male bee—high in the air, when five to nine days old generally, although this time varies. Seminal fluid sufficient to impregnate the greater number of eggs she will deposit during the next two or three years (sometimes even four or five years) is stored at the time of mating in a sac—the spermatheca, opening into the oviduct or egg passage. The queen seems to be able to control this opening so as to fertilize eggs or not as she wills at the time of depositing them. If fertilized, they develop into workers or queens, according to the character of the food given, the size and shape of the cell, etc.; if unfertilized, into drones. The queen's life may extend over a period of four or five years, but three years is quite as long as any queen ought to be kept, unless a particularly valuable one for breeding purposes and not easy to replace. Indeed, if full advantage be taken of her laying powers, it will rarely be found profitable to retain a queen longer than two years.

Upon the workers, which are undeveloped females, devolves all the labor of gathering honey, pollen, propolis, and bringing water, secreting wax, building combs, stopping up crevices in the hive, nursing the brood, and defending the hives. To enable them to do all this they are furnished with highly specialized organs. These will be more fully referred to in connection with the description of the products gathered and prepared by the workers.

The drones, aside from contributing somewhat to the general warmth of the hive necessary to the development of the brood, seem to have no other office but that connected with reproduction. In the wild state colonies of bees are widely separated, being located wherever the swarms chance to have found hollow trees or rock cavities. Hence the production of many drones has been provided for, so young queens flying out to mate will not run too many risks from bird and insect enemies, storms, etc. Mating in the hive would result in too continuous in-and-in breeding, producing loss of vigor. As we find it arranged, the most vigorous are the most likely to reproduce their species.

At the time of the queen's mating there are in the hive neither eggs nor young larvæ from which to rear another queen; thus, should she be lost, no more fertilized eggs would be deposited, and, the old workers gradually dying off without being replaced by young ones, the colony would become extinct in the course of a few months at most, or meet a speedier fate through intruders, such as wax moth larvæ, robber bees, wasps, etc., which its weakness would prevent its repelling longer; or cold is very likely to finish such a decimated colony, especially as the bees, because queenless, are uneasy and do not cluster compactly.

The loss of queens while flying out to mate is evidently one of the provisions in nature to prevent bees from too great multiplication, for were there no such checks, they would soon become a pest in the land. On the other hand, the risk to the queen is not uselessly increased, for she mates but once during her life.

Pollen and honey form the food of honey bees and their developing brood. Both of these are plant products which are only modified somewhat by the manipulation to which they are subjected by the bees and are then stored in wax cells, if not wanted for immediate use. Pollen, the fertilizing dust of flowers, is carried home by the bees in small pellets held in basket-like depressions on each of the hind legs. The hairs covering the whole surface of the bee's body are more or less serviceable in enabling the bee to gather pollen, but those on the under side of the abdomen are most likely to get well dusted, and the rows of hairs, nine in number, known as pollen brushes, are then brought into use to brush out this pollen. When these brushes are filled with pollen, the hind legs are crossed during flight and the pollen combed out by the spine-like hairs that fringe the posterior margin of the tibial joint. The outer surface of this joint is depressed, and this, with the rows of curved hairs on the anterior margin and the straighter ones just referred to, forms a basket-like cavity known as the "pollen basket." Into this basket the pollen falls and with the middle pair of legs is tamped down for transportation to the hive. Having arrived there the bee places its hind legs into a cell located as near the brood nest as possible, and, loosening the pellets, lets them fall into the bottom of the cell. The pellets are simply dropped into the cells and left for some other bee to pack down by kneading or pressing with its mandibles. Often, when partially filled with pollen, the cell is then filled up with honey and sealed more or less hermetically with wax. The bees store the pollen for convenience in feeding above and at the sides of the brood nest and as near to it as possible, the comb on each side of the brood nest being generally well stored with it.

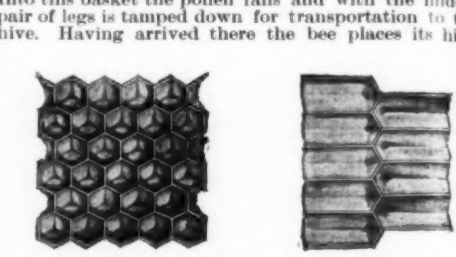
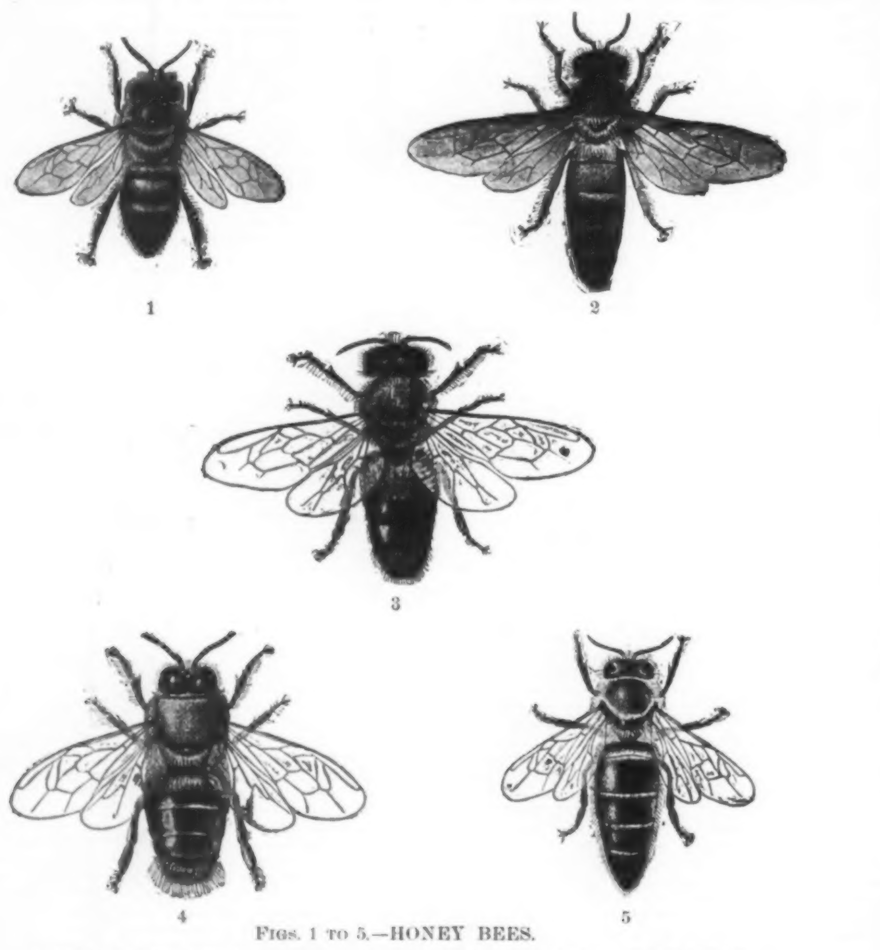


FIG. 6.—WORKER CELLS OF COMMON HONEY BEE (APIS MELLIFICA).

Natural size. (Original.)

The liquid secreted in the nectaries of flowers is usually quite thin, containing a large percentage of water. The bees suck or lap it up from such flowers as they can reach with their flexible sucking tongue, which is one-quarter of an inch long. Fig. 7 shows the digestive system of the bee magnified ten times. This nectar is taken into the honey sac (see Fig. 7 *h s*), located in the abdomen for transportation to the hive. It is possible that a portion of the water is separated from the nectar. Evaporation also takes place in the heat of the hive after the nectar or thin honey has been stored, as it is temporarily, in open cells. Besides being thin, the nectar has at first a raw taste and the general flavor and odor peculiar to the plant from which it was gathered, and these are frequently far from agreeable. To make from this raw product the healthful and delicious table luxury which honey constitutes is one of the functions peculiar to the worker bee. The first step is the stationing of the workers in lines, near the hive entrance. These, by the incessant buzzing of their wings, drive currents of air into and



FIGS. 1 TO 5.—HONEY BEES.

1. Worker, Carniolan variety of Apis mellifica—twice natural size. 2. Giant honey bee of East India (Apis dorsata), worker—twice natural size. 3. Giant honey bee of East India (Apis dorsata, drone—twice natural size. 4. Drone, Carniolan variety of Apis mellifica—twice natural size. 5. Queen, Carniolan variety of Apis mellifica—twice natural size.

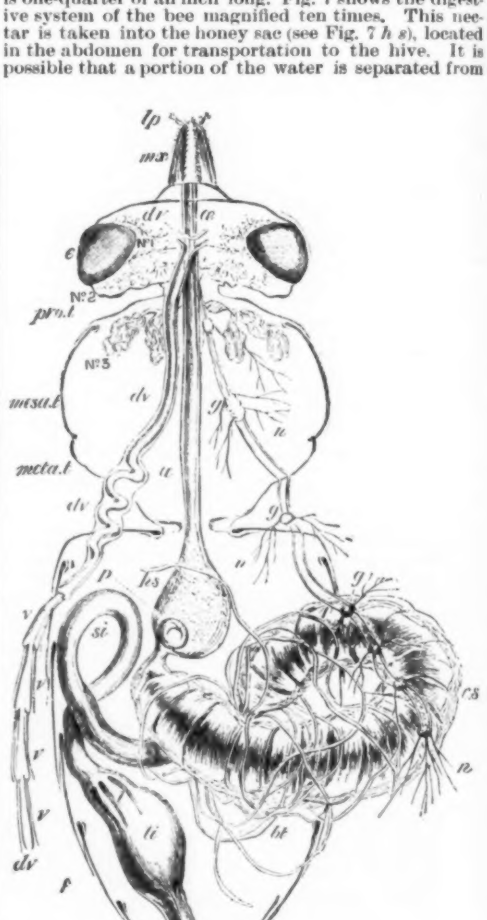


FIG. 7.—DIGESTIVE SYSTEM OF BEE.

A. Horizontal section of body; *lp*, labial palpus; *mx*, maxilla; *e*, eye; *dv*, *dv*, dorsal vessel; *v*, ventricles of the same; No. 1, No. 2, No. 3, salivary gland systems, 1, 2, 3; *œ*, œsophagus; *pro.t*, prothorax; *mes.t*, mesathorax; *meta.t*, metathorax; *g*, *g*, ganglia of chief nerve chain; *n*, nerves; *hs*, honey sac; *p*, petaloid stopper of honey sac or stomach mouth; *c. s*, chyle stomach; *bt*, biliary or Malpighian vessels; *si*, small intestine; *l*, lamellæ or gland plates of colon; *li*, large intestine.

out of the hive and over the comb surfaces. If the hand be held before the entrance at such a time, a strong current of warm air may be felt coming out. The buzzing heard at night during the summer time is due to the wings of the workers engaged chiefly in ripening the nectar. When finally the process has been completed, it is found that the water content has usually been reduced to ten or twelve per cent., and that the disagreeable odors and flavors probably due to volatile oils have also been driven off in a great measure, if not wholly, by the heat of the hive largely generated by the bees. The finished product is stored in waxen cells above and around the brood nest and the main cluster of bees, as far from the entrance as it can be, and still be near the brood and bees. The work of sealing with waxen caps then goes forward rapidly, the covering being more or less porous.

Each kind of honey has its distinctive flavor and aroma, derived mainly from the particular blossoms from which it was secreted, but modified and softened

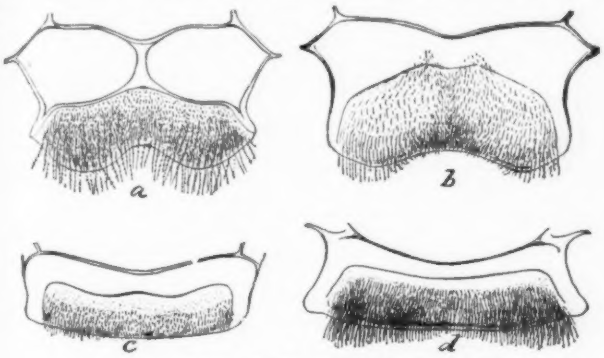


FIG. 8.—WAX DISKS OF SOCIAL BEES.

a, Apis mellifica worker; b, A. mellifica queen; c, Melipona worker; d, Bombus worker—all enlarged. (From Insect Life.)

by the manipulation given it in the hives. When the secretion is abundant in a flower having a short or open corolla, the bees will confine their visits to that kind if the latter is present in sufficient numbers. Thus it is that linden, white clover, buckwheat, white sage, orange, and other kinds of honey may be harvested separately, and it may be readily recognized by its color, flavor, consistency, and aroma. When, however, no great honey yielder is present in large quantity and the source is miscellaneous, all manner of combinations of qualities may exist, introducing great and often agreeable variety. Thus the medicinal qualities and the food value of the different kinds of honey differ as greatly as do their prices on the market.

The substance known as "propolis" or "bee glue" is obtained by the bees from the buds and crevices of the trees, and is carried to the hives in the same way as they carry pollen. The workers, with their mandibles, scrape together the particles of propolis, and with their front and middle legs pass them back to the baskets. The middle legs and feet are used to tamp them down. The pellets can be readily distinguished from those of the pollen, the latter being dull and granular in appearance, while the freshly gathered propolis is compact and shiny. This resinous material, which becomes hard soon after it is gathered, is at first quite sticky, and the bee bringing it requires aid in unloading. Another worker takes hold of the mass with his jaws, and by united exertion they get it out of the pocket, often in small pieces or in long threads. Unlike the pollen and nectar, it is not stored in cells,

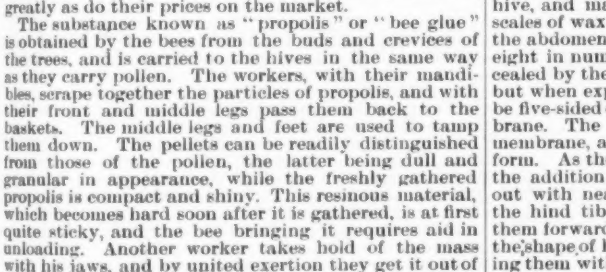


FIG. 10.—CROSS SECTION OF BROOD APARTMENT.

s, s, sides of hive; t, t, top-bars of frames; h, p, l, sb, combs containing (h) honey, (p) pollen, (l) larvæ and eggs, and (sb) sealed brood.

but is used at once to stop up crevices in the hives and to furnish the whole interior surface, as well as to glue movable portions fast; also in strengthening the combs at their attachments, and if the latter are designed exclusively for honey, and specially if not filled at once, the adjacent or completed cells receive a thin coating of propolis, which adds considerably to their strength.

The worker and the queen bee are supplied with another organ which is of great importance to them, namely, the sting, for without this the hard-earned stores of the hive would soon become the prey of marauders and the queen would be deprived of an organ that is of occasional use to her in dispatching rivals and of daily use to her in the working season for the deposition of the eggs. The darts work independently and alternately and are connected at the base with the poison sac, without whose powerful contents such a tiny weapon would be wholly ineffective. The poison glands pour an acid secretion, largely composed of formic acid, into this sac, from whence it is conveyed to the top of the sting along the groove or canal formed by the junction of the sheath and the darts. The sting being but an ovipositor modified to serve also another purpose in addition to the oviposition in the perfect female (the queen); its main use is in placing the eggs in their proper position in the bottoms of the cells.

During cold weather much condensation of moisture takes place in wooden hives as they are usually arranged, and this is generally considered as a detriment, if it occurs too extensively. Later, when no condensation takes place in the hive and the greater number of developing larvæ require a considerable supply of water in their food, special trips are made to brooks and pools for it, and dew is often gathered from leaves.

The light-colored pellets which are carried into the hive on the hind legs of the workers, and which have been described as pollen, are often mistaken for wax. The fact is, wax is not gathered in the form in which

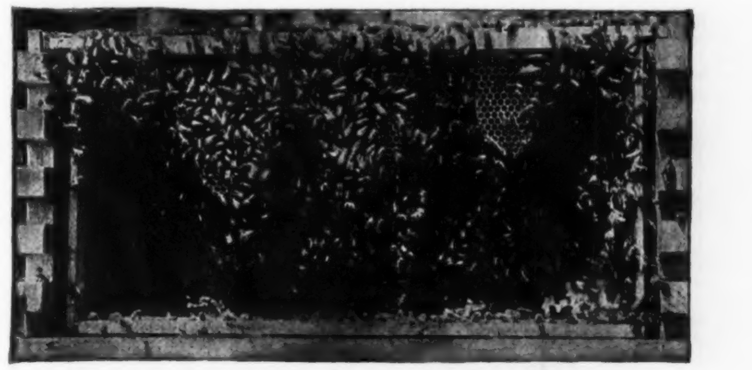


FIG. 9.—COMB BUILDING—SIDE OF HIVE REMOVED.

we see it, except in rare instances, when, bits of comb having been left out, small quantities will be loaded up and taken in as pellets on the legs. Ordinarily, it comes into the hive in the shape of honey and is transformed by the workers with their own bodies into wax. This production is wholly confined to the workers, for, although the queen has wax plates on the underside of the abdomen and wax glands beneath them, yet both are less developed than in the workers and are never used. The wax plates of the worker overlie the secreting glands, as shown in Fig. 8. During wax secretion, that is, when combs are being built or honey cells sealed over, a high temperature is maintained in the hive, and many workers may be seen to have small scales of wax protruding from between the segments of the abdomen on the underside. The moulds, or plates, eight in number, in which the scales appear, are concealed by the overlapping of the abdominal segments; but when exposed to view, as in a, Fig. 8, are seen to be five-sided depressions lined with a transparent membrane. The wax glands themselves are beneath this membrane, and through it the wax comes in a liquid form. As these scales harden, they are pushed out by the addition of wax beneath. The bees pluck them out with neat pincers formed by the articulation of the hind tibiae with the adjacent tarsal joints, pass them forward to the mandibles, and mould them into the shape of hexagonal cells, and warming and moistening them with the secretions of the head glands to render the wax more pliable.

Wax is fashioned by the workers into cells of various

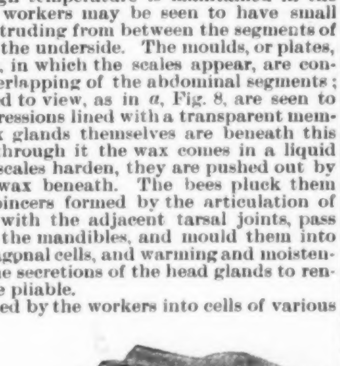


FIG. 11.—QUEEN CELLS AND WORKER BROOD IN VARIOUS STAGES.

sizes and shapes, according to the use to be made of them. The most regular in shape and size are the cells designed for brood. These combs, in which workers are bred, show nearly twenty-nine cells on a square inch of surface, the combs being ⅞ inch thick and the cells generally quite regular hexagons in outline. Drone cells are larger, there being but eighteen of them to the square inch of surface, and the comb is 1¼ inches thick. The cells of combs designed only for honey are frequently more irregular in shape, generally curve upward somewhat, and are often deepened as the honey is stored in them, so that these combs sometimes reach a thickness of 2 or 3 inches.

The cells in which queens are bred bear in size and shape some resemblance to a ground or pea nut. They are often irregular in form, being sometimes curved, or short and thick, according to the space below their point of attachment, which is most frequently the lower edge or the side edge of a comb, or sometimes a mere projection or angularity in the general surface of a comb. Queen cells open downward instead of being built horizontally like drone and worker cells (Fig. 11).

Into the material used in constructing brood combs bees often incorporate bits of wax and fiberlike gnawings of cocoons from old combs in which brood has been reared, and if given cappings or trimmings of combs they will work them all over and utilize most of the material. Also when the bees have abundant supplies of pollen much of this is incorporated into the material of brood combs, thus saving the costlier substance—wax. Such combs show at once by their brownish or straw color, even when first constructed, that they are not made of wax alone. It will readily be seen from the above that the quantity of honey consumed by the bees in producing a pound of comb must vary greatly, for if the comb is designed for surplus honey it will be made of newly secreted wax, while if for brood other material will, as just stated, replace a portion of the wax. The amount of honey coming in varies from day to day, and it is difficult to estimate how much is consumed in feeding and keeping warm the brood; moreover, a high temperature is required in the hive to facilitate the secretion and working of wax, necessitating, of course, extra food consumption when the outside temperature is low. Accordingly estimates as to the amount of honey required to produce a pound of comb range from 5 pounds to 25 pounds. More accurate experiments are needed in this direction before anything positive can be stated. Until then 18 to 20 pounds might be looked upon as nearest the correct figure for white surplus combs, and half as much for dull straw colored, or brownish combs built for brood rearing.

Ordinarily the winter cluster in a hive of bees occupies the more central combs, four or five in number. Near the middle of this cluster the queen deposits the first eggs of the season (which are fertilized eggs) in the small sized or worker cells. Under favorable circumstances, that is, in a strong colony amply protected against inclement weather, this deposition generally occurs in January, though in a very mild climate some brood is generally present during every month of the year, and the cessation of egg laying is very short. The eggs hatch on the third day after deposition into minute white larvæ, to which the workers supply food in abundance. The composition of this food has been the subject of much attention and more theorizing. It may be considered as pretty certain that during the first three days of the life of the larva its food is a secretion from glands located in the heads of the adult workers—a sort of bee milk, to which, after the third day, honey is added in the case of the worker larvæ, and honey and pollen in the case of drone larvæ. As this weaning proceeds, both worker and drone larvæ receive pollen, and in constantly increasing proportions, in place of the secretion. But this rich albuminous substance is continued to the queen larvæ throughout their whole period of feeding; moreover, the quantity of this food supplied to each queen larvæ is apparently superabundant, for after it ceases to feed quite a mass of the food somewhat dried out will be found in the bottom of the cell from which a well developed queen has issued. After assuming the pupa form the young queen is attached to this food by means of the tip of the abdomen, and it continues for some time to receive nourishment from the mass.

The following table shows approximately the time occupied in the development of worker, drone, and queen:

	Egg.	Larva.	Pupa.	From deposition of egg to imago.
	Days.	Days.	Days.	Days.
Queen	3	5½	7	15½
Worker	3	5	13	21
Drone	3	6	15	24

The original circles of brood are gradually increased by the deposition of eggs in the cells next outside those already occupied, and circles are soon begun in the adjoining combs. In this way the space occupied by the developing bees is gradually increased, while preserving the general spherical shape of the brood nest thus formed, which, however, the shape of the hive often modifies somewhat. As already mentioned, each circle of brood has rows of pollen cells about it, chiefly above and at the sides, and the combs on either side contiguous to the brood are usually well packed with pollen. Outside of the pollen most of the honey on hand is stored. Thus (Fig. 10) a cross section made in any direction through the middle of a hive in normal condition at the opening of the active season should show this relative arrangement of brood, pollen, and honey, which economizes most the heat of the hive and the labors of the nurse bees, favoring in this way the rapid increase of the population.

The worker larvæ are fed five days, and then the cell is given by the adult bees a covering which is quite

porous by reason of numerous pollen grains incorporated into its mass, this openness of texture being necessary to give the developing bee air to breathe. The larva strengthens this capping by a loose webwork of silk within, extending down the side but slightly and attached at its edges to the last skin cast by the moulting larva. This skin, extremely delicate and pressed closely against the inside of the cell, forms the lining of its sides and bottom. In about twelve days after sealing, that is, twenty-one days from the time the egg was deposited, the imago, or perfect bee, bites its way through the brown covering.

In the course of a couple of days it takes up the work of a nurse, and in a week to ten days may appear at the entrance on pleasant days, taking, however, but short flights for exercise, as ordinary field work is not undertaken until it has passed about two weeks in the care of brood. The worker then takes up also wax secretion, if honey is to be capped over or combs built, although old bees can and do to a certain extent engage in wax production.

Eggs left unfertilized produce drones and require twenty-four days from the time they are deposited until the perfect insect appears. They are normally deposited in the larger sized horizontal cells, and when the latter are sealed, the capping is more convex as well as lighter colored than that of worker brood, which is brown and nearly flat.

The fact that drones develop from unfertilized eggs is to be noted as having an important practical bearing in connection with the introduction of new strains of a given race or of new races of bees into an apiary. From a single choice home-bred or imported mother, young queens of undoubted purity of blood may be reared for all of the colonies of the apiary, and since the mating of these young queens does not affect their drone progeny, thereafter only drones of the desired strain or race and pure in blood will be produced, rendering, therefore, the pure mating of future rearings fairly certain if other bees are not numerous within a mile or two. Eventually also all of the colonies will be changed to the new race and without admixture of impure blood, provided always that the young queens be reared from mothers of pure blood mated to drones of equal purity.

TUBERCULOSIS IN ANIMALS.*

By W. HUNTING.

ONCE every month the daily papers publish extracts from the returns of the Registrar-General showing the causes of mortality among the population of these islands. When typhoid, smallpox, or scarlet fever destroy an extra hundred of human lives, popular attention becomes arrested, and, should the mortality continue, public agitation soon arises. A dozen deaths from hydrophobia in one year is the signal for issuing most stringent regulations—enforced by fine or imprisonment. One case of suspected cholera in any of our ports is sufficient to cause something approaching panic. A report that a ship has reached our coast, and that a death has occurred on it from plague, is an event noticed by every newspaper in the country.

All this is well known, and the general public approve of the stringent measures taken by our authorities—central and local—to prevent further loss of human life. The diseases mentioned are dangerous plagues, and it is in accordance with reason and common sense that every precaution should be taken to prevent their spread. The public appreciate the danger, and the legislature has provided measures of protection.

There is a disease that destroys more human beings than all the plagues I have named put together. There is a disease the returns of mortality never mention—a disease about which the press and the public are apparently ignorant, and which the legislature ignores.

We constantly hear of typhoid, smallpox, and cholera, but we seldom hear of tuberculosis outside of medical books. The absolute want of knowledge of the disease is what protects it from any public movement, and from all legislative interference. At Marlborough House last December Sir William Broadbent stated that 70,000 persons die every year in Great Britain and Ireland from tubercular disease. Why is the death of 100 persons from typhoid, or of a dozen from hydrophobia a cause of popular indignation, while the death of thousands every month from tuberculosis goes on unnoticed and unchecked? The explanation is that the public recognize the preventability of those diseases but not of this. The loss from one is slow, obscure, and constant. The loss from the others is sudden, evident, and occasional. We all know the dangers of smallpox, typhoid, and hydrophobia; we take what precautions we can, and look to legislation for assistance in limiting their spread. The greatest of all plagues is lost sight of—its very name is unused, and it is disguised in the published returns of mortality by inclusion in "disease of the respiratory organs," or "disease of the digestive organs." To class a specific disease like tuberculosis in this way is as logical as to include smallpox in the list of "diseases of the skin." Such returns defeat the object of publicity—they disguise a grave public danger instead of exposing it. Seventy thousand deaths per annum from one disease—one preventable disease—is a terrible event; more terrible from the fact that no public alarm is raised and no legislative attempt is made to stay its progress.

But what has this to do with the subject of my paper? What has human mortality to do with bovine tuberculosis? A very great deal. Tuberculosis in cattle is one of the causes which leads to the annual hecatomb of human beings, a cause which might be most easily removed. Sir Richard Thorne, in a lecture delivered last November, drew attention to the fact that during the last half century a great reduction in the death-rate from many forms of tuberculosis in man had taken place. This he attributed to the improved sanitary arrangements now adopted—to improved ventilation, to better hygienic surroundings, and to less overcrowding in houses and workshops. When, however, the statistics were examined of those forms of tuberculosis which were not from infection through the lungs but through the stomach, it was found that no decrease was apparent. On the contrary, the mortality of children under one year old from abdominal tuberculosis had increased, and this increase had gone hand in hand with the steady increase in the consumption of cow's milk. No other explanation can be found for this constant annual slaughter of the innocents except infected milk, and the medical profession accept the cause pointed out by the chief medical officer of the government.

What is tuberculosis? It is a disease affecting man and animals. It is due to the existence of a living organism—a microbe—in the system of the victim. It spreads solely by the transmission of the microbe from diseased to healthy bodies. The usual method of human infection is by a person suffering from consumption, i. e., from tuberculosis affecting the lungs. Another method is the ingestion of infected flesh and milk derived from tuberculous cattle. A Royal Commission sat for four years inquiring into this question, and reported in 1895 that the danger of infection from tuberculous milk is a serious one, while the danger from tuberculous meat, though slighter, must not be disregarded.

Here then is authoritative evidence showing the connection between tuberculosis in man and in animals. The degree of danger depends upon the extent to which disease prevails among cattle, and there is reason to believe that at least 20 per cent. of the cattle over two years old are more or less affected with tuberculosis. In some districts the disease is almost unknown, in others it is common. Cows kept for milking purposes show the greatest amount of infection, and some sheds have been found in which 60 per cent. of the stock was infected.

The two channels through which tuberculosis may be transmitted from cattle to human beings are meat and milk. Each is worth a little separate consideration.

MEAT.

Under various public health acts some attempt has been made to protect the public from the danger of consuming tuberculous meat. Sanitary inspectors, acting under the direction of medical officers of health, may seize diseased meat in shops or slaughter-houses, or wherever it is exposed or prepared for sale. Where animals are killed in public abattoirs inspection is easy, and when the inspector understands his duties—which is seldom—no dangerously diseased meat is likely to escape seizure. In this country by far the larger proportion of meat is prepared in private slaughter houses, where inspection practically does not exist, and where its proper performance would entail the appointment of a small army of inspectors. All infected carcasses are not equally dangerous. Tuberculosis may be indicated in one animal by a few nodules in one organ, in another by a general disease implicating the whole body. The latter state requires seizure of the whole carcass; the former may be treated as a local infection and the carcass passed after removal of the diseased organs. Between these two extremes of infection every imaginable degree of disease distribution is to be met with, and the decision as to whether a carcass should be seized in whole or part becomes a question for an expert. When inspection has been lax, or the inspector incapable, much dangerous meat has been passed for human consumption. On the other hand, when inspection has been based upon the theory that any visible infection of a carcass contaminates the entire body, great hardship has been inflicted upon butchers by confiscation of the whole animal.

There are few cattle in which the detection of tuberculosis is difficult after death. There are many in which during life no sign of disease is discoverable, but which prove on examination after slaughter so extensively diseased as to render the carcass unfit for human consumption. Hence arises a serious hardship to the butcher, who, after honestly purchasing an apparently healthy animal, has the carcass seized by the authorities. It is argued that this loss to the butcher must be looked upon as an ordinary trade risk, and that while he is deserving of sympathy, he must not be allowed to sell meat which is a grave danger to human life. Not unnaturally the butcher replies: "I am not to blame. I bought an apparently perfectly healthy animal, and only discovered the dangerous condition after slaughter. The public health should certainly be protected—but at the public cost. My property may be justly seized, but in equal justice I should be compensated for it." I shall refer to this question again, but here I would point out that the effect of seizure without compensation is to drive away from slaughter houses where inspection takes place all the suspected or diseased animals which the owner thinks—be he butcher or not—might fail to pass inspection. The worst tuberculosis carcasses do not go to public abattoirs, but they find their way through private slaughter houses to the kitchens of the meat consumers. Fortunately, thorough cooking renders tuberculous meat harmless, but not everyone is satisfied with an overcooked joint.

The controversial question of having only public slaughter houses I have no time now to discuss. It is a very large one and includes much more than the detection of tuberculous meat. Public abattoirs in towns are of little use if private slaughter houses are permitted to remain, or even if meat killed outside the town is allowed to enter by road or rail without inspection. To protect the public completely from tuberculous meat by inspection would require the total prohibition of private slaughter houses and prohibition of movement of carcasses until officially stamped. For other reasons this may be found advisable and practical, but as a protection against tuberculosis, it would be more cumbersome and costly than the stamping out of the disease.

MILK.

The transmission of tuberculosis from animals to man by means of infected milk is a much more serious danger than the possibility of infection by meat. Large quantities of milk are consumed uncooked, and constitute a grave danger. Especially is the danger from this cause imminent for infants and young children, or for invalids weakened and debilitated from a recent attack of typhoid or scarlet fever.

Not every tuberculous cow produces impure milk. It seems, in fact, that only those animals which have tubercular disease of the udder yield infective milk. If the specific condition of the udder were always prominent and easily detected, the danger might be guarded against by removal of the cow, but it is not so. The disease commences insidiously, progresses rapidly, and infects the milk in the gland in its very early stages. Milk from a tuberculous udder is virulently infective, and one case is recorded where half a wineglassful mixed with the food of two rabbits caused their death from general tuberculosis in a few weeks.

In a remarkably able paper by Dr. Niven, the medical officer of health for Manchester, read before the meeting of the Sanitary Institute at Birmingham last year, some definite information concerning the infection of milk is given. From this paper I take the following:

In Liverpool, 144 samples of milk from city cow sheds were examined, and 29 per cent. were found to contain tubercular infective matter. Of 24 samples of milk taken at the railway stations, 2 per cent. was infected.

In Manchester, the milk from 19 tubercular cows was examined; that from 5 contained tuberculous infection, and all 5 cows had tuberculous udders.

In Manchester, 93 samples were taken at the railway stations, and 18 per cent. were found by Prof. Delapine to contain tubercular infective matter. By permission of the farmers from whom these infected milks were received, Mr. King, the city veterinary officer, examined the cows on 16 farms. On 14 of them at least one cow was found with disease of the udder.

"It thus appears," says Dr. Niven, "that at the present time an enormous stream of infectious milk is pouring into our cities, and that the matter is truly one of urgency."

That this grave condition is urgent and serious will be better understood when I say that at present there are no powers afforded by law for the seizure of cows in the last stages of tuberculosis, although their udders are loaded with disease, and their milk is mixed daily with the produce of large cowsheds.

Probably enough has been said to show that tuberculosis in animals is a danger to public health, and at the same time a cause of great loss to butchers and cow keepers. Neither butchers nor cow keepers have any interest in owning diseased animals. They sustain nothing but loss through them, and are unable to avoid purchasing them. The disease prevails widely in the stock owned by breeders and feeders, from whom the cow keeper and butcher must obtain the necessary animals to carry on their business. It is essential that human life should be protected against the transmission of disease by meat and milk, but the most stringent inspection of cow sheds and slaughter houses will not affect the prevalence of disease outside those places. By thorough inspection and ruthless seizure of diseased products in the possession of butchers and cow keepers, partial protection may be given to public health, but so long as disease in the stocks of breeders and feeders of cattle is left untouched, so long will fresh supplies of infected animals enter the places from which the direct supply of food for man is obtained.

The usages of trade do not provide for warranties of soundness on the sale of cattle. The diagnosis of disease is impossible in fairs and markets. The butcher who buys an animal for the production of meat and the cow keeper who buys stock for the production of milk have no ready means of self-protection against the seller of tuberculous cattle. If the public is to be protected against disease, it is unfair to place the whole cost of such protection on the shoulders of the butcher and cow keeper, while the breeder and feeder, who have full opportunity for recognizing the state of their stock, are allowed to keep diseased cattle and sell them without restriction and without loss.

The agriculturist is, however, himself a sufferer, and deserves all the assistance that can be given him. Tuberculosis causes continuous loss to him through abortion and sterility, through wasting disease and death, through the interference with fattening and the excess of food required to feed diseased animals. Although probably 20 per cent. of the adult cattle of the country are more or less infected, only about 1 per cent. show visible signs of the disease, and prove a total loss in any year. If we take the cattle stock of the kingdom at 6,500,000, and put aside those under two years old as being very slightly affected, we have 4,000,000 animals concerning which the estimate may be made that 1 per cent. are distinctly diseased—unfit either for meat or milk production. This would put the annual loss from bovine tuberculosis at 40,000 animals, and is sufficient to warrant legislative assistance and control.

Firm control of the disease would be an advantage to all classes. Public health and national wealth would both benefit by the suppression of a plague that injures all and does good to none. Regulations for its control are loudly called for by every interest, but most loudly by the requirements of public polity. Every one who has given the subject a little thought is satisfied that something ought to be done. Some would trust in voluntary effort, others insist on the necessity of legislative action. Let us examine both methods.

VOLUNTARY EFFORT.

Without some voluntary effort on the part of stock owners legislation can achieve little. Voluntary effort alone has never yet stayed the spread of contagious disease among animals. Carelessness, ignorance, and greed are not peculiar to any classes of the community, and until human nature is exempt from these vices only the best of men will endure trouble and loss for the protection of others' interests. The easiest and most profitable method of getting rid of contagious disease in animals is to pass it on to your neighbor by selling the stock in the open market, and thus increasing the spread of infection. There is no law to prevent it, and the approval of thick-and-thin advisers of voluntary effort will doubtless be given. The public by voluntary effort may protect themselves against the dangers of tubercular infection from meat and milk. This can be done by well boiling all milk before consuming it, and by thoroughly cooking all meat before eating it. This is so simple that logically the public have not very strong grounds for insisting that meat should be free from the tubercle bacillus. It is harmless when cooked, and so everyone can protect himself. And yet no one has objected to the provisions of the public health acts which provide for the seizure of tuberculous meat!

Again with milk, safety can be obtained by boiling, and yet Sir William Broadbent claimed in his speech at Marlborough House that "the public had a right to insist that their milk should be absolutely free from the tubercle bacillus."

The supporters of purely voluntary action should

* Journal of the Society of Arts, London

apply to the consumers of meat and milk the same arguments they enforce when the owners of diseased cattle are referred to. If we are to do nothing by law save when self-protection is impossible, let us do nothing all round. I expect this argument will gain few supporters. It will be said that we want meat and milk without the addition of a virulent poison; that overcooked meat and boiled milk are not palatable, and some will agree with me that the digestion of meat and milk is not assisted by excessive cooking.

The butcher, the cow keeper and the agriculturist may do a great deal by voluntary effort to guard themselves against disease in their animals and at the same time to protect the public.

Before I discuss what they may do, it will be necessary to say something about the means we have at our disposal for the detection of disease.

A few years ago it was quite impossible to detect the majority of cases of tuberculosis in any animal. The majority of cases are always those which have not yet caused any marked disturbance and which present no indication of their existence to the ordinary observer. Tuberculosis is usually of slow development. After infection, months may pass during which no indication of the disease is given, but a post-mortem examination would reveal distinct lesions in perhaps many parts of the body. Every infected animal has a chance of spontaneous recovery, and a still greater chance of existence for a time without apparent injury. During the stage of latent disease, while lesions are developing in the body and centers of infection gradually increasing, many exciting causes come into play, give rise to systemic disturbance and distinct appearances of disease. Probably during the latent period of tuberculosis not much danger of infection to other animals exists, but in those cases where the lungs or bowels are implicated it is impossible to say at what time infective virus may be expelled by coughing or may escape with the excreta. The detection of the advanced cases, which afford visible symptoms of disease, is not difficult, and they may be removed from the possibility of infecting other animals. It is clear, however, that the spread of the disease can only be controlled by detecting the latent cases before they reach the stage at which they constantly transmit infection. Having detected them, they must be submitted to such isolation as will prevent their contaminating healthy stock when they reach that stage of disease which is surely contagious.

A few years ago this was quite impossible, but now, thanks to Dr. Koch's discovery of tuberculin, every infected animal can be rapidly detected and provision made for suppressing any transmission of disease. The tuberculin test for tuberculosis in cattle has, by innumerable experiments, been established on a firm foundation as harmless, yet trustworthy. In a few hours it is possible to determine, on a farm or in a shed, which animals are infected and which are not. Then they may be separated and the diseased kept strictly by themselves.

By voluntary effort the agriculturist is able to detect the existence of tuberculosis in his stock, to separate the healthy from the infected, to keep only healthy animals, and to dispose of all the diseased.

Prof. Bang, of Copenhagen, has demonstrated the practical success of this method on a large scale, and has even shown how a breeding stud of infected animals may be continued for years without implicating the offspring, if care be taken to avoid contagion. Sir Gibson Carmichael, in Scotland, adopted this voluntary method on his pedigree stud at Castlecraig and has now a herd free from tuberculosis. The late Lord Vernon, at Sudbury, quite recently put into practice the tuberculin test, followed by weeding out the infected, with great success. The Duke of Westminster and the Earl of Crewe have also given practical approval to this method. A number of other private owners have partially adopted it and a few have gone so far as to detect all their infected stock by means of tuberculin, and then have disposed of them so that less knowing men may enjoy the loss they have evaded. Supporters of the "voluntary system" too often describe the tuberculin test and its proper sequelæ as simple, easy, and efficacious. It is indeed efficacious, but it is far from simple and easy. The use of tuberculin requires, first of all, a trained veterinary surgeon for its application. This means expense. Next, the separation of infected stock must be carried out, and this means space for the purpose and extra buildings for isolation. To sell all the infected animals is a "dirty trick," if it is not reckless waste, as many would not be in condition for the butcher. Valuable breeding cows could be kept for their special services, but only under conditions which are available to rich men, or on places where sheds and pastures are unlimited. The voluntary suppression of tuberculosis on a farm by the tuberculin test and rigid separation is at present only practical for rich men and philanthropists. It is quite possible if capital and space are obtainable. It is even profitable under those conditions and where the stock is one of valuable pedigree animals.

In town cow sheds, the provisions for isolation do not exist, besides which it is next to impossible to prevent the reintroduction of disease by newly purchased cows. Furthermore, there is no inducement to keep only non-infected cows. The customers will not pay an extra price for pure milk, and even public institutions such as schools, hospitals, etc., offer no encouragement to a cow keeper, either by extra payment or by compulsory regulations, to guarantee purity. There is, too, less commercial inducement for the cow keeper than for the breeder to employ tuberculin and thorough voluntary effort. The breeder keeps his stock for years and need seldom introduce animals from without. The cow keeper retains his only so long as they yield a full supply of milk, and then he replaces them by new purchases from farmers and breeders. Tuberculosis runs a slow course, and, therefore, may occasion little loss by spreading among animals when a year is the average time of their existence.

When the public awaken to the danger of tuberculous milk, the legislature will be obliged to insist upon the absence of tuberculous cows from milk sheds. Then the cow keeper will be forced to adopt measures of self-protection. He will have to clear his herd, and he will have to guard against the constant risk of purchasing infected cows. He may do this by a trade combination insisting upon all purchases being warranted free from tuberculosis. The individual who attempted to enforce such a warranty at the present time would fail to obtain the stock he required to carry on his business, or he would have to pay from three to four pounds per head more for them. A strong trade combination might enforce a warranty, but the effect of such action would at first be to give the careless and dishonest man the pick of the best milkers on the market. This would right itself in time, because the negligent buyer would soon have evidence of disease in his shed, and suffer accordingly. The cow keeper who bought on a warranty could only insure the value of it by testing his new purchases with tuberculin. The warranty would have a time limit, so that the vender might not be unfairly treated. But even with this care, and supposing a trade combination could be effected, the voluntary effort would not be safe. Any one can obtain and use tuberculin; after a few injections the reaction ceases or becomes very dubiously indicative. Dishonest dealers might by repeated injections render cows immune against reaction, and then a cow keeper would have no means of defense against tuberculosis even if he had a warranty. Voluntary effort is insufficient, and unless the law steps in to assist honest traders, the public must continue to face the risk of tuberculous milk.

The butcher is at present in the worst position, because the law provides penalties for the sale of diseased meat. The law puts no restraint on tuberculous disease affecting animals in farms or in cow sheds, but it seizes the infected carcass when it comes into the possession of the butcher. The butcher buys what he believes to be a healthy beast; he is unable to detect disease during life, which may be laid bare by post mortem examination, but he has to suffer for whatever the meat inspector detects. How is the butcher to apply voluntary effort? There are only two methods open to him. He may form trade combinations to purchase only on a warranty of freedom from disease—not, of course, an absolute freedom, but such a practically sound condition as will enable an inspector to pass the carcass in whole or part. This is being tried in some districts, but is very difficult to enforce, as the salesmen throw in their lot with the farmers to oppose the butchers.

Another plan which is being tried, but which has not made much advance, is for the butchers of a district to form a mutual insurance fund, as is done by shipowners. So much a head on all purchases is paid to the fund, and all loss sustained by seizure at the slaughter-house is made good from the fund. This would be a fair system if the venders of animals also subscribed, but it is only paying out of one pocket into the other when butchers alone found the fund. It pleases some people to talk of the loss from contagious diseases of animals as "a trade risk," and of insurance by butchers against it as a thing quite analogous to insurance by shipowners. This argument takes no notice of an extremely important difference. No regulations, either voluntary or legislative, will ever put a stop to storms and accidents at sea. They are an inevitable trade risk which cannot be suppressed, and can only be insured against. With contagious diseases of animals there is no such inevitable and unpreventable condition. The same argument prevailed for a time when the cattle-plague invaded this country in 1865—the disease spread, herds were exterminated, and stock owners ruined. Then stamping out with liberal compensation was tried, and in a few months the plague was exterminated. Similar measures have been attended with success in the case of two other serious diseases — pleuro-pneumonia and foot and mouth disease. Contagious diseases of animals are more than a trade risk, they are a national disaster, and should be faced as such. They are preventable and, in time, extinguishable. By man's ignorance disease has been allowed to spread—by man's knowledge it can be controlled. All classes may well be called on to share the expense of suppressing a widespread disease, if it can be shown that it is a public danger, and can be controlled at a reasonable cost, and within a reasonable time. The butcher, the cow keeper, and the agriculturist must all be called upon to use due care, and to put up with some unavoidable loss, but the public may also be logically included among those who pay the cost of legislative measures beneficial to all.

(To be continued.)

DO WE AGE MORE SLOWLY THAN OUR FORBEARS DID?

By W. AINSLIE HOLLIS, M.D., Physician to the Sussex County Hospital.

"Ah me! what wonder-working occult science
Can from the ashes of our hearts once more
The rose of youth restore?"

—*Longfellow.*

THE rate at which we grow old varies to some extent with the individual. The progressive structural defects which eventually constitute the decrepitude of old age are for the most part the results of casual or preventable incidents during a man's previous life. Zymotic disease plays an important part among the agents which can initiate those local changes so conducive to early senility and death. The statistics published by the late Sir George M. Humphry* shortly before his death show as a rule that they live longest who have escaped the bodily infirmities commonly attributed to old age. Joint stiffness is one of these ailments.† Owing to their anatomical and functional peculiarities, the joints are specially liable to injury from blows or as the result of bacteric infection. Yet of the nonagenarians mentioned by Humphry, 84 per cent. had natural joints. Again, 74 out of 162 old people had attained the same great age without the occurrence of any serious illness whatever, while of the remainder, 33 had been attacked by some form of infectious disease, mostly late in life. The freedom from "after-effects" which such histories imply doubtless contributed to the subsequent longevity. The practical hygiene of modern life has removed many of the causes which led to the epidemic outbreaks in former ages. During the past half-century the "middle arch of life" has advanced in age from about forty years to nearly fifty.* This means an enormous improvement in the health of the nation and a corresponding delay in the manifestations of senility, inasmuch as they mainly depend upon various structural defects due to unhealthy surroundings. The late appearance of any conventional tokens of old age, such as baldness and loss of teeth, both commonly attributable to the action of pathological microbes, must not, however, be regarded as indicating a possible extension of the period of adolescence beyond the usual time. Whether this extension can and does take place will be discussed hereafter; meanwhile we must accept all such signs as those enumerated, not as evidence of aging, but of preventable bacterial infection which may show itself at any moment. Any indications of youthfulness which the absence of these first fruits of modern pathology may render conspicuous must be the work of the natural laws which govern growth and development in a healthy individual and not in a senile freak.

Hitherto we have considered the process of aging in its relationship to the casual incidents of life; and we have seen what a large share morbid anatomy has in fashioning the popular concept of old age. Improved sanitation will doubtless in a future generation sweep away many, if not all, these evidences of passing ailments in old people; and so far it will check the premature development of those popularly accepted badges of antiquity above referred to. There are, however, at certain epochs of life, definite physical changes in our bodies which mark time as it were and are yet uninfluenced by health and cleanliness—at all events, not to any marked extent. I allude to such incidents as the eruption of the milk teeth in predetermined order, and to their subsequent replacement by the permanent teeth; to the changes which take place in the human eye whereby the amplitude of its accommodation, which is greatest at the early age of twelve years, diminishes steadily, until at the age of seventy-three years it is entirely lost; to the changes of puberty and of the grand climacteric; and finally to the union of the shafts of the various long bones to their respective epiphyses (which marks the cessation of growth and the time limit of adolescence. These incidents, inasmuch as they are phases in the normal development of our bodies from youth to old age, must not be placed in the same category as the others which we have previously considered. For whereas the latter are variable as to the date of advent in different persons and are inconstant in their results, any permanent alteration in the time-limits of the former will betoken probably some racial or evolutionary change of significance.

As the period of adolescence which terminates on the cessation of growth appeared in many respects to lend itself most readily to fairly exact observation both in man and in other mammals, several well-known gentlemen interested in the breeding and rearing of farm and other live stock were communicated with and some new and valuable information was obtained. It was found in the first place that man has, either by domestication or artificial selection, shortened the duration of the adolescence in certain breeds of farm stock.† It is obviously to the interest of breeders in the case of those species which form an important part of the food supply of the nation to rear animals which arrive at maturity quickly. Accordingly we find that certain breeds, such as Shorthorns and Herefords among cattle, Oxfords and Hampshires among sheep, Middle-white pigs, and Dutch and Polish rabbits arrive at full growth sooner than some other varieties of the same species. The demand for young horses, although urgent, is apparently not quite so pressing; yet according to my informant, a well-known breeder of English thoroughbreds and Shire horses, the former, which "are considered in their prime at the end of four years but grow even after that," are slower to mature than the latter. On the other hand, Mr. Wilfrid Blunt, to whom I am indebted for a most interesting letter, writes: "An Arab horse does not, as a rule come to maturity till his eighth year. . . . He is at his prime at twelve."

It is, of course, difficult to determine the potential longevity of any particular kind of farm stock. It may be nevertheless of some interest to find from the same sources a general consensus of opinion that the breeds with a shortened youth die usually at an earlier age than the others whose adolescence is more extended. A gentleman farmer writes: "My experience tells me that by continued selection for early fatting properties the Shorthorns and Herefords are not able to stand hard and poor living so well as Highlands and Welsh and do not live so long." Prof. Blundell, of the Royal Agricultural College, Cirencester, informs me that "Mountain sheep live more naturally upon herbage, while Oxfords and Hampshires lose their teeth earlier and are unable to keep up their condition. . . . I think if both classes of sheep—such as Oxfords and the Mountain breeds—were allowed to go on until they die naturally, the Mountain breed would live the longest, but this has not been settled by experimental test." As regards rabbits, Mr. F. W. Walker, the well-known breeder of Angoras, considers that "the Polish and Dutch breeds are six weeks forwarder in maturity than some other kinds of rabbits," and that "such varieties (i. e., Polish and Dutch) have a natural tendency to live less time" than other breeds.

From the above evidence it is clear that man has by his essays in selective breeding "hurried up," as our American cousins might put it, the developmental processes of certain varieties of live stock by shortening the term of their youth. By so doing he has probably shortened the natural span of their lives also. On the other hand, I cannot find any certain proofs that the adolescence of a breed has ever been intentionally lengthened. I have little doubt if the attempt were seriously made that it would be successful. Open air life appears, however, to be productive of long-lived, slow-growing breeds. Highland and Welsh cattle, Mountain Scotch and Mountain Welsh sheep, and

* "Old Age:" the Results of Information received respecting nearly Nine Hundred Persons who had Attained the Age of Eighty Years, including Seventy-four Centenarians. London: Macmillan & Bowes, 1889.

† "My joints are somewhat stiff" (Tennyson).

* Dr. Farr, in the Thirty-fifth Report of the Registrar-General, describes the march of an English generation through life. The age between forty-five and fifty-five years is the middle arch of life. For a few months after the age of forty-five a million children born at the same time are reduced to half a million. "This age is now extended to forty-nine." A Treatise on Hygiene and Public Health, by Stevenson and Murphy.

† In man the sternal end of the clavicle and the crest of the ilium are not united to their respective bones until the age of twenty-five years. (Legal Medicine, by the late C. M. Tidy, M.B.) This age represents the limit of adolescence.

Arab horses are slow to mature and are long-lived breeds. Heredity seems to participate in the production of some long-lived domestic breeds. The English thoroughbred matures more slowly than the Shire horse reared under similar conditions and a long-wooled Angora rabbit will usually outlive a Dutch coney born at the same time and under the same roof. Yet it is difficult to understand how a breed of domestic animals can without the knowledge or the wish of a breeder become decidedly longer-lived than some other varieties of the same species.

From what has been stated above it seems probable that among certain mammals a direct relationship exists between the duration of adolescence of a breed and its potential longevity. In other words, the slowly-maturing varieties are the longer-lived breeds. If now we pass from the varieties of species to the species themselves, we shall find that a similar relationship exists in their case also. It is demonstrable that in certain extreme examples some such rule must be in operation. Many years ago M. P. Flourens, in a work on Human Longevity, concluded that the average age of a mammal was five times the period occupied in growth. Buffon had previously supposed that the ratio was as 7 to 1. In neither case are the data sufficiently numerous or trustworthy to make these statements credible and in accordance with experience.

Let us now take a few examples of well-known domestic mammals of different species and compare the ratio of the length of their youth with that of their life. The potential longevity of a domestic mouse is—according to my authority, a breeder of these small rodents—about four and a half years, while it is full grown at the age of three months. The mouse, therefore, spends about sixteen times the span of its youth as an adult animal. Man, on the other hand, whose adolescence ceases at twenty-five, lives rarely beyond eighty years*—in other words, under favorable conditions, he can only hope to pass in adult life fifty-five years, or a little more than twice the length of his adolescence. When an animal is taken for comparison, such as an Arab horse—whose youth, although longer than that of a mouse, is yet shorter than that of a man—the ratio of the two periods in this instance is as eight years to forty, or as 1 to 5, so far conforming to Flourens' requirements. Yet the Arab steed passes four-fifths of its life as an adult.

In the Fifty-ninth Annual Report of the Registrar-General of Births, Deaths, and Marriages there are a series of tables on the age and constitution of the married of both sexes. From 1874 onward the proportion of marriages of minors has, with few exceptions, decreased year by year, and the mean of the recorded ages has, with very few exceptions, increased. Taking the twelve years immediately preceding the year 1897, when the statistics were most trustworthy, "between the first and the last of these years the increase in the proportion of bachelors married at ages between twenty-five years and forty years was so large as to balance not only the whole of the decrease, amounting to 57 per 1,000 marriages under the heading 'Age not stated,' but also a decrease of 30 per 1,000 marriages at ages below twenty-five years. This undoubtedly indicates a general increase in the ages at which bachelors marry. . . . Among spinsters the proportion who marry at ages above twenty-five years has also increased, but the increase is somewhat less in amount than it is among bachelors."† These figures may be considered too few to be conclusive, yet the deferment of marriage among bachelors until adolescence is passed is too decisive a fact to be ignored.

The group of famous veterans who continue to uphold their early reputations despite the active competition of younger men forms one of the most striking features of the present era. What age before this has produced a pathologist like Virchow, who with youthful energy, despite his seventy-seven years, came from Berlin to London in order to deliver an oration in a foreign tongue on the most recent discoveries of medical science? Can another generation show a veteran composer like Verdi, who at eighty-five years of age still fills the world with tuneful melody, or a pope with an intellect more active and a judgment more shrewd than those enshrined in the frail body of Leo XIII., two years older than Verdi? At the beginning of the present year The Daily News published a series of articles on the world's old people, entitled "How to Live Long." The general impression one gets, according to the writer, is that upon the whole the world's old men "have been rather a Bohemian set, with hardly any hygienic principles and a strong inclination 'to do as they darned please.'" It is not surprising that the infirmities of age should be less in evidence now than formerly, when we know their relationship to preventable disease. The energy, however, which enables a man to take his full share in the active duties of life at the age of fourscore years and upward implies something more than mere freedom from decrepitude. It implies a control of brain and limbs which an unusually prolonged youth alone can give. If mankind is subject to the same law that apparently regulates the potential longevity of a mammal by the duration of its adolescence, this expansion of youth is to be looked for where a green old age is common. We have learned elsewhere that there are indications that a change of this kind may be taking place among the inhabitants of these islands.

There is no doubt that the prolonged operation of such a law as I have endeavored to describe must eventually lead to the remodeling of the whole scheme of social life. The improved sanitary conditions of modern times and the gradual education of the people in the science of living will lead to the postponement of those tokens of age which are commonly attributed to senility but are really the outcome of disease. The healthy surroundings and the freedom from the conventional trammels of old age will possibly increase among our immediate descendants the tendency to the extension of the period of adolescence beyond our own—an extension which our life tables show to have already set in. Whether the progressive slowing of man's growth and development will continue until youth usurps the whole of a long life to accomplish its behests, cannot yet be answered. The pendulum of life swings backward as well as forward.—Lancet.

* Dr. Farr estimated the average duration of life as seventy-five years for those above fifty-one years of age.

† Op. cit., p. xv.

THE

Scientific American Supplement.

PUBLISHED WEEKLY.

Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50 stitched in paper, or $3.50 bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers, 361 Broadway, New York.

TABLE OF CONTENTS.